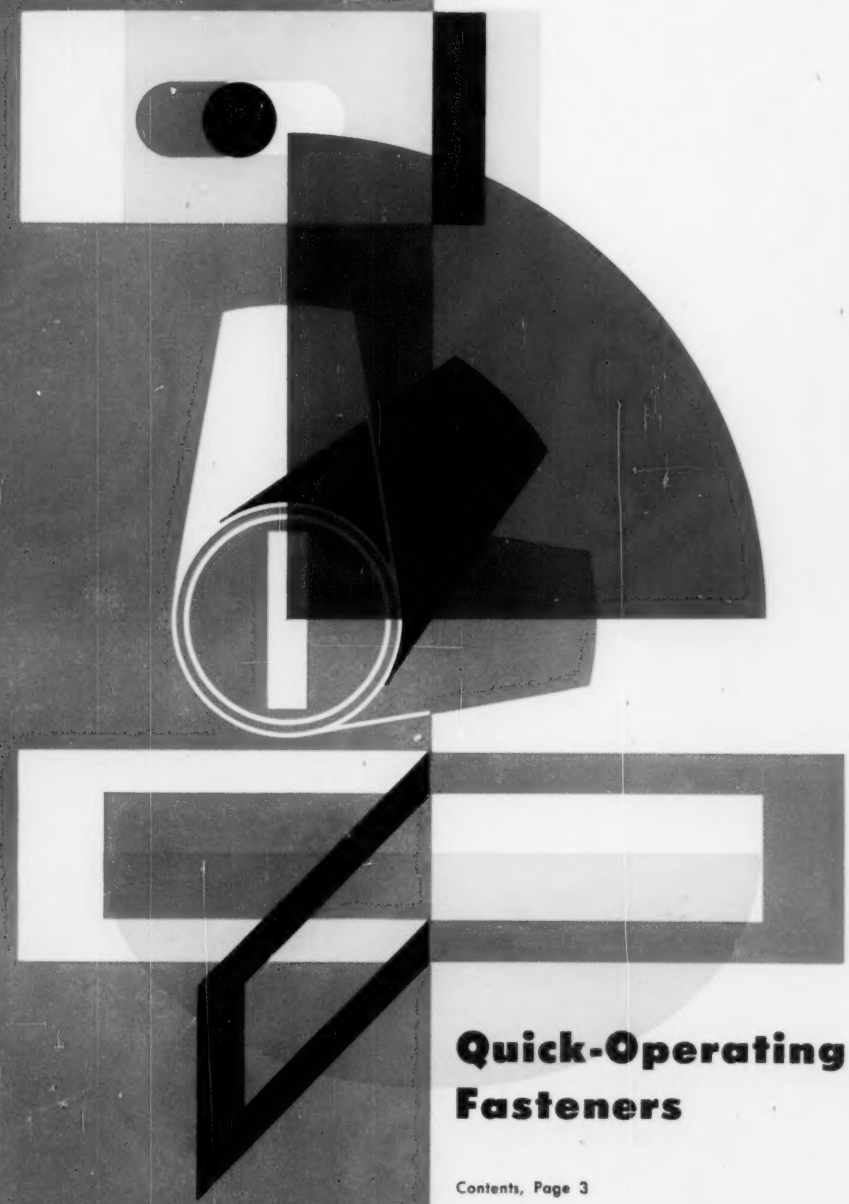
DECEMBER 25, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

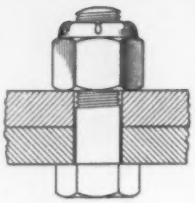


Quick-Operating Fasteners

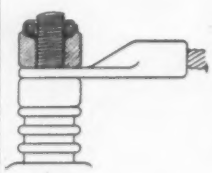
Contents, Page 3

Ten fastening problems solved by ELASTIC STOP® nuts

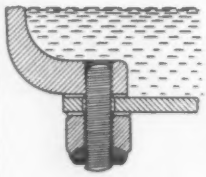
TIGHTENED AGAINST THE WORK



Vibration and impact proof bolted connections in standard applications.

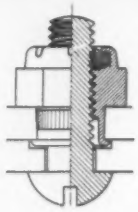


On all electrical terminals subjected to vibration in transit or operation, and for any electrical or electronic assembly where positive contact must be maintained.

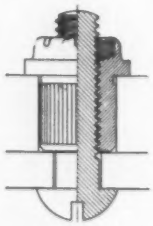


To seal bolt threads where leakage past stud threads must be prevented.

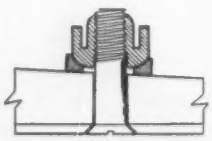
FOR MANY SPECIAL FUNCTIONS



Blind fastening applications where nut is "clinched" into sheet metal . . . becoming self-retaining as well as self-locking.

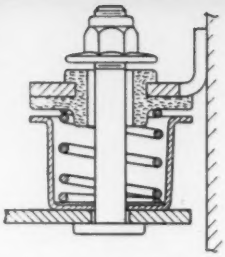


To eliminate drilling and tapping and provide steel thread strength for soft metals, an ESNA spline nut is pressed into a bored hole in casting.

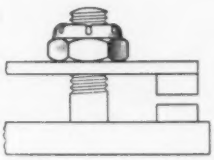


Simplified self-aligning self-locking fastener for bolting two non-parallel surfaces.

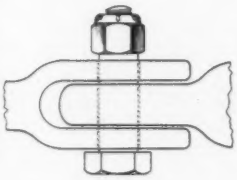
LOCKED ANYWHERE ON THE BOLT



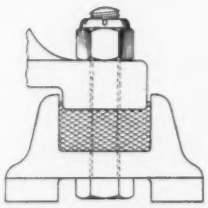
Spring-mounted connections or dynamic balancing, where nut must stay put yet be easily adjusted. (Flanged face eliminates need for extra washers.)



On make and break adjustment studs where accurate contact gaps must be maintained. Note "thin" height design for limited clearance.



For bolted connections requiring predetermined play.



For rubber-insulated and cushion mountings where the nut must not work up or down.

HOW THESE NUTS SOLVE SO MANY FASTENING PROBLEMS, ELIMINATING EXTRA PARTS AND OPERATIONS...

The red locking collar of an ELASTIC STOP® nut grips bolt threads with a perfect fit that will not loosen under severe vibration or stress reversals, and seals against liquid seepage. By bringing nut and bolt metal thread flanks into firm contact it eliminates wear producing axial play. The elastic locking action of the insert-type stop nut does not distort or gall bolt threads. It is reusable many times.

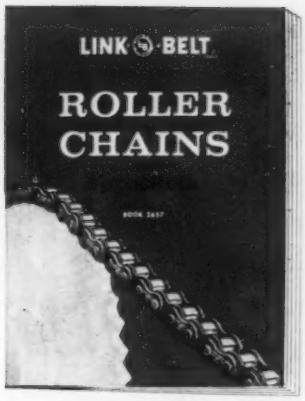
Send for the following free information: Elastic Stop nut bulletin; Rollpin® bulletin. Or enclose a drawing of your product for specific self-locking fastener recommendations. Write to Dept. R40-124.

Circle 481 on Page 19

ESNA®

ELASTIC STOP NUT CORPORATION OF AMERICA
2330 VAUXHALL ROAD, UNION, NEW JERSEY

NEW roller chain engineering data book



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Front Cover: Not an abstract study but "moving" images of three basic types of quick-operating fasteners provide the theme for George Farnsworth's cover design on this issue. A more down-to-earth look at these devices is offered by assistant editor Jim Parks' guide on Page 85.

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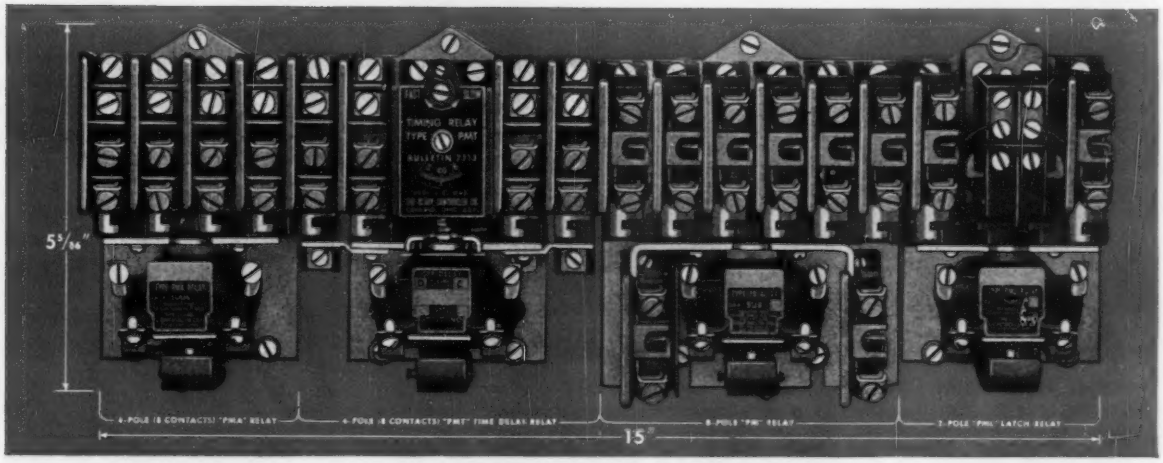
NOW CLARK OFFERS THE MOST COMPLETE INTEGRATED LINE OF CONTROL RELAYS AVAILABLE TODAY!



UNIVERSAL POLE RELAYS

up to 14 contacts per relay

New Clark Universal Pole Relays now double the available number of contacts per relay. Each universal pole contains two isolated contacts—one normally open, one normally closed. Melamine barriers and spacing provide 600-v clearance between contacts. Contacts have 10 ampere rating and wiping action. Universal poles are interchangeable with convertible poles of "PM" relays.

Line up with other Clark relays on a panel!

TIME DELAY RELAYS

2 or 4 timed contacts —up to 6 instantaneous contacts

New Clark Pneumatic Time-Delay Relays match physically other relays in the "PM" line. Timing head occupies the space of 2 poles above magnet. Universal poles each have isolated normally open and normally closed contacts, with 600-v clearance. Timed and instantaneous poles are identical. Available for "ON-DELAY" or "OFF-DELAY" operation (time delay after energization or de-energization), and easily convertible.

Line up with other Clark relays on a panel!

CONVERTIBLE POLE RELAYS

2 to 12 poles

The original line of space-saving control relays featuring exclusive Clark "modular construction". Revolutionary design provides 10 standard units with 2 to 12 poles, from 5 basic models. Stocking of relays and spare parts is greatly simplified. Poles are easily converted from normally open to normally closed and vice-versa. Individual poles are front removable without disturbing wiring.

Line up with other Clark relays on a panel!

LATCH RELAYS

2 to 10 poles

New Clark mechanically-held, latched-in relays have same modular design as "PM" relays—with latch unit occupying the space of two poles above magnet. No increase in height—saving panel space. Latch unit has its own continuous duty coil, allowing one more pole for circuit use since a relay pole is not needed to cut out coil when energized for sustained periods.

Line up with other Clark relays on a panel!

Detailed descriptive bulletins are available for all relays in the Clark "PM" line. Contact your nearest Clark sales office or write us direct.

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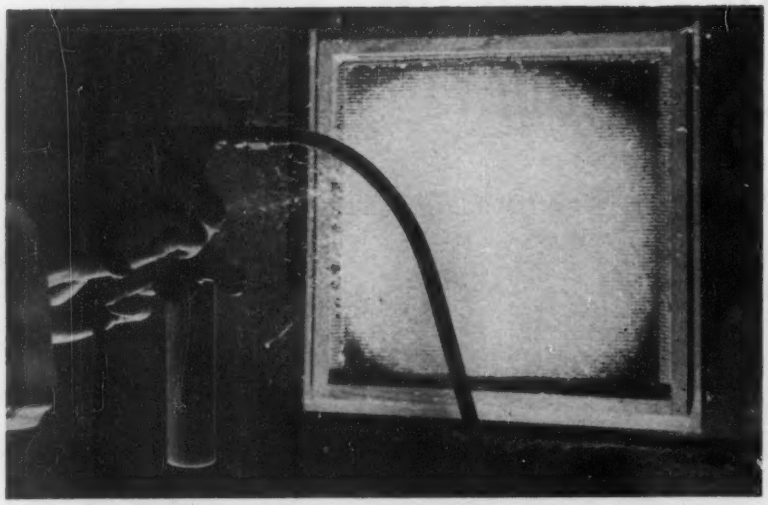
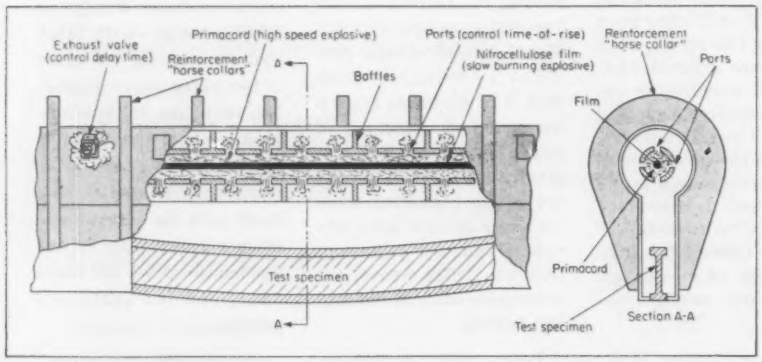
ENGINEERING NEWS



Twenty-Thousand(ths) Tiny Filter Traps Capture Submicron Particles

Capturing submicron-size radioactive particles (down to 0.01 mu) for fall-out measurement is the job of a superfine-fiber filter developed by Stanford Research Institute, Menlo Park, Calif. The new filter—which can be burned away for analysis of the residue—has promising applications in air cleaning and sampling service. Photo shows how the filter is built up. A solution of polystyrene is sprayed against a Dacron mesh. When the spray hits the air, the solvent instantly evaporates, depositing a bed of 1-mu fibers on the mesh. Rolling the mat upgrades cohesion and strength. Collection efficiency is very high (99.5 per cent), and pressure drop through the filter is said to be reasonable.



Atomic Blast Simulator

Fast-burning powder and scrap nitrocellulose movie film are set off in a pressure chamber to simulate the blast of an atomic bomb. The unit was designed by Boynton Associates, La Canada, Calif., to test the strength of components under atomic blast without subjecting them to radiation contamination. It successfully duplicates the characteristic quick build-up and slow decay of pressure associated with an atomic blast. The charge, fast-burning primacord for the quick build-up, and slower burning scrap film to help sustain heat and pressure for a slower decay, is put in an inner firing tube equipped with ports to vent the blast to the main pressure chamber at a controlled rate. A test specimen like the beam shown is mounted in an extension of the main pressure chamber beneath the firing tube where it receives the desired stress.

Aluminum Cooling Systems Pose New Problems for Auto Industry

GM Spokesman Urges Study of Coolant-Metal Chemistry

NEW YORK — Aluminum radiators and engine blocks may demand a change in the chemistry of coolants, according to a General Motors spokesman. Although rust-inhibitors and antifreezes now in use work well in today's automobiles, the increased use of aluminum in cooling systems will present corrosion problems that call for new techniques. Pitting and galvanic corrosion are sure to be more in evidence.

GM suggests that chemical manufacturers take a new look at these problem areas:

- Effect of water quality on corrosion and inhibition.
- Effect of heat transfer on metal corrosion.
- Effect of hot spots and surface boiling on metal corrosion.
- Effectiveness of inhibitors in crevices and low coolant velocity areas.
- Effect on corrosion of service variables such as maintenance quality, antifreeze re-use, and driver habits.

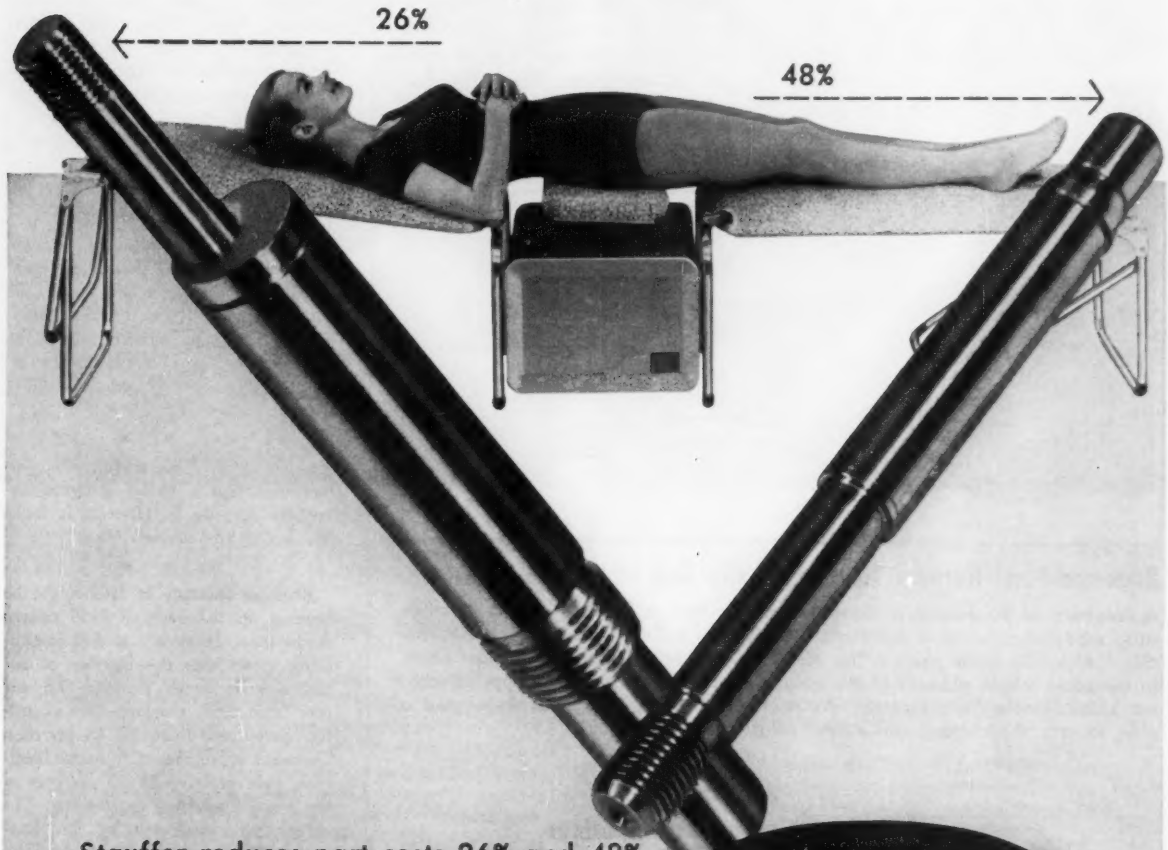
The auto industry is already studying some of these factors. When light metals are introduced into the engine cooling system, continued corrosion-free service can be provided if the necessary preparatory steps are taken now, according to GM.

NASA Takes Command of Army's Jet Propulsion Laboratory

WASHINGTON — California Institute of Technology's famed Jet Propulsion Lab—one of the prime movers behind Army's spectacular success in missiles and space research—has been transferred to NASA. The $55,-million complex of plant and equip-

SHE is improving her figure on a Stauffer "Magic Couch." And although she doesn't know it, Stauffer makes two of the Magic Couch's most important operating parts from LaSalle ground and polished STRESSPROOF® steel bars. This means that her Magic Couch will last longer, will be more dependable.

Stauffer reduces cost figures, too!



Stauffer reduces part costs 26% and 48% by using today's improved ground and polished...

STRESSPROOF®
STEEL BARS
WITH COPPER

ELIMINATES Heat Treating

This eccentric shaft . . . and this idler shaft, two of the most important parts of Stauffer's Magic Couch, were formerly made of heat treated C-1137. But Stauffer design engineers recommended a change to LaSalle ground and polished STRESSPROOF® steel bars . . . with copper.

The result: no need for rough grinding . . . no need for expensive heat treating. Production costs were reduced 26% on the eccentric shaft . . . 48% on the idler shaft.

Today's improved ground and polished STRESSPROOF® can help your per-part cost. It gives high strength without heat treating . . . it machines 50% to 100% faster than heat treated alloys . . . it minimizes warpage . . . it makes a better part at a lower cost.

To find out how STRESSPROOF® can help you, just write for a copy of the newly published bulletin, "Today's Improved LaSalle Stressproof Steel Bars . . . with copper." Or for production applications, ask for a sample bar for test purposes.

La Salle STEEL COMPANY

1426 150th Street, Hammond, Indiana

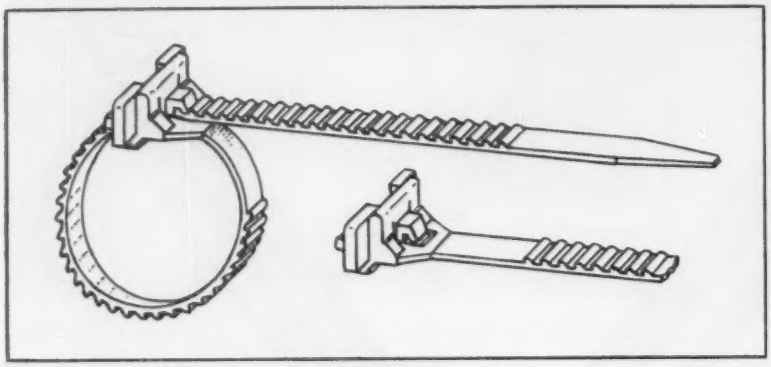
Circle 407 on Page 19

ment, with its staff of 2300 top scientists, engineers, and supporting personnel, has been a major supplier of knowledge and hardware to Werner von Braun's Huntsville team since the Army entered the space age.

Reason for the transfer: NASA didn't have the facilities to carry out its new responsibilities. The only alternative would have been to duplicate JPL, a task that would have required untold sums of money, plus an almost impossible personnel-recruiting program.

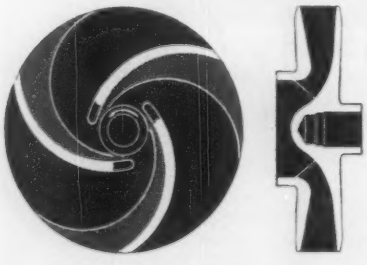
The transfer involved a fair amount of behind-the-scenes give and take—the net result being that NASA took JPL and gave up its claim to Huntsville.

Under the new setup, Huntsville will undertake a certain amount of research for NASA, and will in turn receive co-operation from NASA's new Jet Propulsion Lab.



Rack-and-Pawl Harness Tie Has No-Slip Grip

A reduction of 30 percent in harness bundling time is possible with a rack-like strap made of nylon-base Moldarta. Tooth form allows bending to 1/32-in. radius. A double-tooth pawl in the buckle gives a holding strength almost equal to the basic tensile strength of the strap. Although the tie can be applied without special tools, its originator, Westinghouse Electric Corp., has developed a plier to grip the tie and clip excess strap after installation.



New Pump Has No-Choke Blades

Vapor lock and loss of prime in highly volatile fluids are stopped by the unique impeller design of a new centrifugal pump. Impeller-passage areas —fixed by blades with chords greater at tip than at root—diverge toward periphery instead of converging. Fluid sweeps out from tips faster than it is replaced at the root, allowing entrained gases and vapor to pass through without blockage. Called Vapor-flo, pumps are produced by Ingersoll Rand Co., Phillipsburg, N. J.

No-Sweat Landings Now Fully Automatic

ATLANTA, GA. — Eventual end to aircraft stack-ups over closed-in airports may be in sight if Bell Aircraft's fully automatic landing system lives up to expectations. Currently under evaluation by Lockheed for eventual incorporation in the B-47, the system promises to revolutionize IFR (Instrument Flight Rule) landing techniques.

Heart of the system is an automatic radar tracking beam, which tracks approaching aircraft down to the runway and supplies position information to an electronic computer on the ground. The computer compares the actual flight path with the flight path desired for the aircraft under control and radios appropriate correction signals to the plane's autopilot. The system will land anything from Cubs to jets.

Topics

Wondering where the yellow went is a thing of the past—at least in the case of fading yellow paint. Two new pigments, containing nickel as the stabilizing ingredient, retain their color even in temperatures over 1000 F, are light-fast, and alkali and acid-resistant. Of all paint colors, yellow has always been especially susceptible to the ravages of sunlight, heat, moisture, and corrosive atmospheres. Nickel in the new Harshaw Chemical Co. pigments contributes to high durability and chemical-resistant qualities, as well as imparting the yellow color.

• • •

Accommodating escalator moves either up or down, depending upon whether its passenger got on at the bottom or top. One of these round-trip stairways has been installed by the Chicago Transit Authority for bi-directional use by commuters during nonrush hours.

• • •

Under "C": One maker of coffee machines has a model designed especially for use in offices. It looks like a gray file cabinet.

• • •

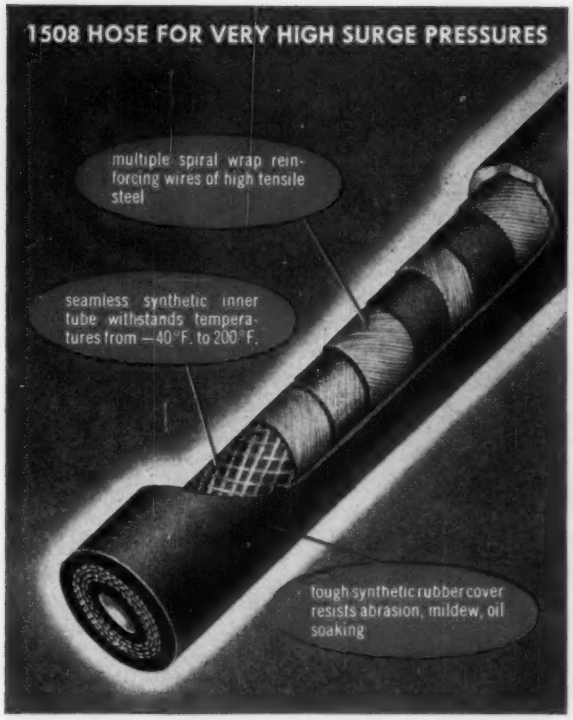
Engineer shortage in 1962 might be forecast on the basis of 1958 college enrollment. A survey of 944 institutions shows that the number of engineering freshmen dropped 7.6 per cent from 1957, although over-all college enrollment increased 7.1 per cent. Decreases in number of full-time freshmen were reported by 70 per cent of the schools teaching engineering. The survey was conducted by Dr. Raymond Walters, president of the University of Cincinnati.

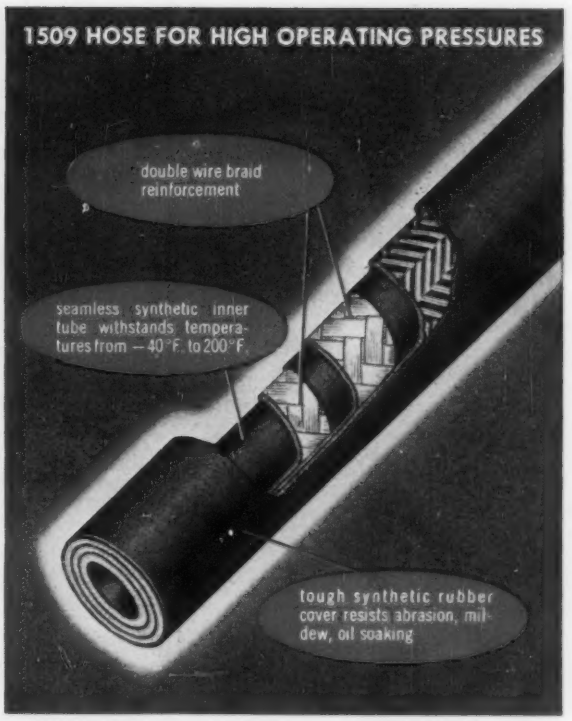
• • •

Electronic animal husbandry is expected to aid in producing better beef more economically. A Bendix computer used by researchers at the University of Arkansas will be programmed to determine and interpret trends in production of beef cattle. Statistical data projected over generations of cattle will guide breeders.

• • •

Gas-powered steam engine runs "for free," driving a water pump at La Gloria Oil & Gas Co., Houston. The flow of natural gas is the source of power; an engine operating on a normal steam-engine cycle acts as a reducing valve between the high-pressure gas dehydrator discharge line and low-pressure feed to a transmission pipeline. No gas is consumed or lost to the atmosphere. The system was devised by La Gloria and the Troy Engine & Machine Co., Troy, Pa.


1508 HOSE FOR VERY HIGH SURGE PRESSURES
multiple spiral wrap reinforcing wires of high tensile steel
seamless synthetic inner tube withstands temperatures from —40°F. to 200°F.
tough synthetic rubber cover resists abrasion, mildew, oil soaking


1509 HOSE FOR HIGH OPERATING PRESSURES
double wire braid reinforcement
seamless synthetic inner tube withstands temperatures from —40°F. to 200°F.
tough synthetic rubber cover resists abrasion, mildew, oil soaking

Design High Pressure Fluid Systems Up to 5000 psi.

WITH AEROQUIP FLEXIBLE HOSE LINES

Aeroquip offers two basic hose types to meet most high pressure fluid line requirements:

1508 Hose with wire wrap reinforcement
1509 Hose with wire braid reinforcement

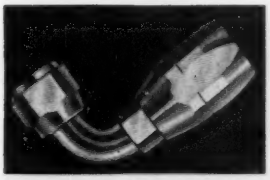
Engineering tests indicate that the braided hose reinforcement is ideal on systems with 'normal' operating pressures up to 5000 psi., while the multiple spiral wrap hose reinforcement affords longer service life on systems subject to abnormal or frequent surge pressures.

In addition, the spiral wrap construction of 1508 hose gives it longer life than braided hose under severe operating conditions such as constant flexing, heavy vibration and shock.

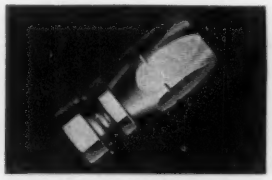
All Aeroquip Hose Fittings are detachable and reusable. They are designed to provide leakproof performance even at burst pressure of the hose.

Call on Aeroquip to furnish any type of special fitting or tubing configuration to solve your piping problem. Our extensive engineering and manufacturing facilities enable us to furnish fast delivery on specials.

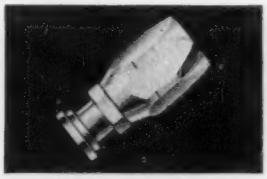
Get full product information on Aeroquip High Pressure Hose Lines by returning the coupon below. If you have a specific fluid line problem, outline your requirements and an Aeroquip Sales Engineer will call on you.



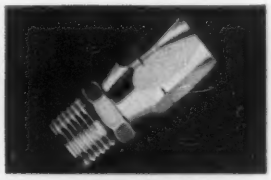
Standard Elbow Fittings
¼" to 1" in swivel nut, 1½" to 2" in split flange and standard 4-hole flange ends



J.I.C. Swivel Fittings
¼" to 2" sizes



Split Flange Fittings
(O-ring shoulder) ½" to 2"



Male Pipe Fittings
¼" to 2" sizes

Aeroquip

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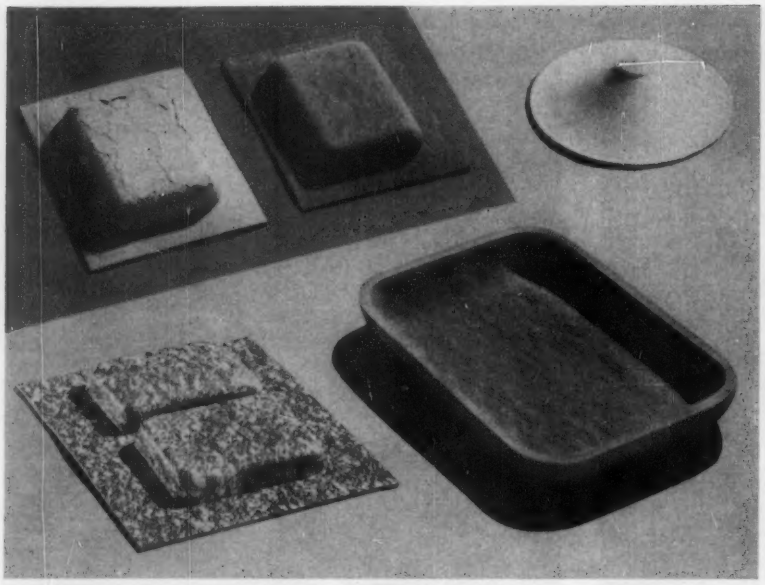


Structural Paper

Laminated, high-strength kraft paper is easily formed into an array of shapes and products in a new process developed by Cincinnati Industries Inc., Cincinnati, Ohio. The paper, called X-Crepe, is especially treated and laminated with thermoplastic resins into a single-layer or multiply material. Thickness ranges to more than ¼ in. Almost any design or color can be imprinted into the material, and the plastic content provides a hard, decorative finish for inside and outside surfaces. Machined-steel and cast-epoxy molds have been used in producing a number of paper products, with forming done on air-pressure machines that blow the heated material into molds. Typical paper products are shown above, together with a comparison of formability of the new X-Crepe material with that of conventional untreated kraft paper, upper left.

Storage Batteries: Five-Cent Size

Almost unlimited life can be expected from these rechargeable nickel-cadmium cells. The tiny hermetically sealed units are about the size of a five-cent piece, weigh ¼ oz, and come in two ratings: 0.18 and 0.10 ma, both with an open-circuit voltage of 1.2 v. The cells can be stacked into batteries and connected in series or parallel, depending on power requirements, and can momentarily discharge currents up to 10 times their rated capacity. Recharging a single cell requires a constant current equal to 1/10 of the cell's normal capacity. Gulton Industries Inc., Metuchen, N. J., developed the miniature power source for use in missiles, but the cells are also being designed into a variety of new portable consumer products.

Atom Angles

Tombs for dead Pharaohs . . . cost no more than atom-age cemeteries for high-level radioactive waste material, according to Ritchie Calder, consultant for the World Health Organization. In the last 14 years, the U.S. alone has accumulated and stored 60 million gal of radioactive "leftovers" in more than 100 indestructible steel tanks. The cost so far has been $65 million. Some radioactive wastes will remain dangerous for decades, others for centuries and, in the case of plutonium, for at least 24,000 years.

But the deep six . . . 1000 fathoms down in the Gulf of Mexico, has been approved by AEC as a safe disposal ground for low-level wastes of the sort generated by medical, industrial, and general research programs. Typically, such debris is made up of residual solutions from experiments, contaminated filter paper, broken test tubes, and carcasses of animals used in biological experiments. For high-level waste disposal, however, recent findings have indicated that even the 4-mile deep trenches in the world's oceans are unsafe "cemeteries."

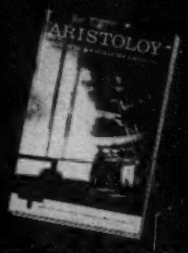
AF's air transportable reactor . . . to be built in 1959, will be erected at Sundance Air Force Station, Wyoming. AEC and AF invited proposals in October for design, development, construction, and operation of this plant. Scheduled to test the feasibility of factory-assembled modular reactors, the 1000-kw nuclear power and heating plant will be designed to allow air transportation to the site.

Jeeps and Geiger counters . . . along with their prospector-owners, are going to have to settle for less glamorous work than uranium hunting. AEC, which up until now has paid out $8 a pound for all uranium produced, has announced it will no longer guarantee a market for newly discovered U. S. deposits. Trouble isn't with an actual surplus; AEC must slow down skyrocketing domestic production so that it can continue to buy under firm contract with the Belgian Congo, Canada, Australia, and South Africa.

Atoms in the Antarctic . . . may convert the ice box of the world into a valuable resource, says Dr. Bernard I. Spinrad, director of Argonne Laboratory's Reactor Engineering Div. He points out that "the thermodynamic efficiency of a generating plant increases as heat-rejection temperatures are lowered." Nuclear fuels not only minimize transport problems associated with fossil fuels, but make possible the construction of massive atomic power stations that take thermodynamic advantage of the Antarctic's subzero temperatures.

ARISTOLOY

Electric Furnace Steels



NEW PRODUCTS & FACILITIES CATALOG
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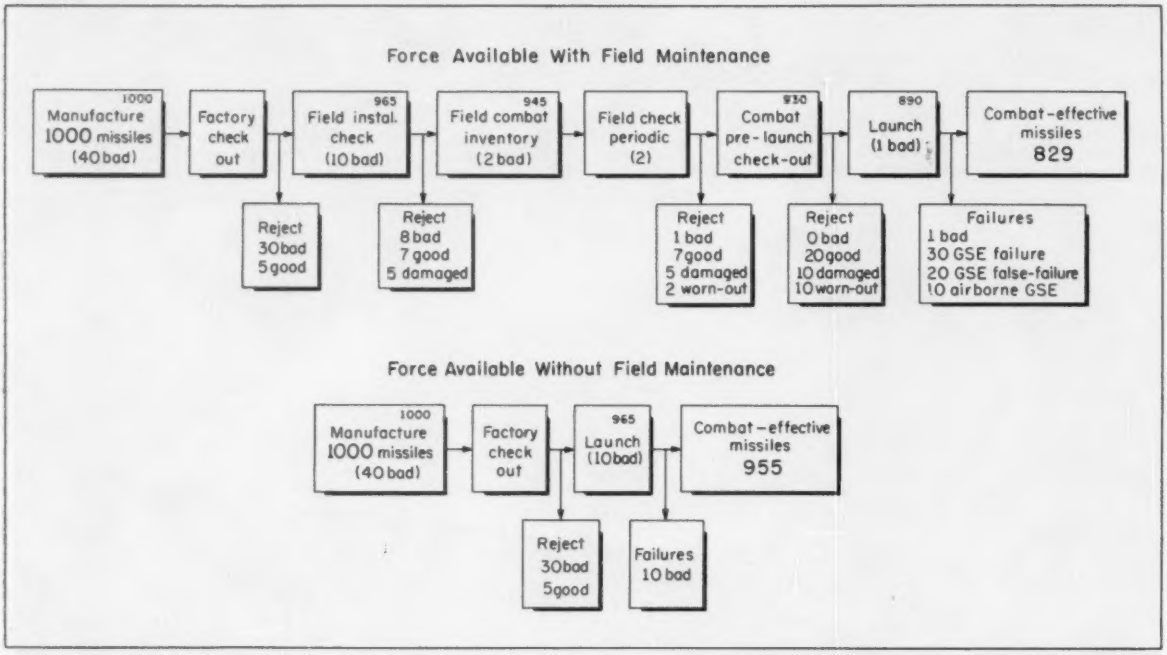
Hands-Off Policy May Muster More Missiles

DETROIT—Factory to launching pad without "benefit" of field checkout by armed-forces personnel may be the way to put more and cheaper missiles on the target. This was the observation of Space Technology Laboratories' L. G. Ludwig, addressing the Vickers' 1958 Aircraft Hydraulics Conference.

Observing that "requirements for servicing provisions in recent components and systems have resulted from frustrations of the services over basic unreliability of components," Ludwig expressed doubt that the desired quick and major increase in reliability could be attained by a field checkout program intended to detect, reject, and/or repair the "bad eggs."

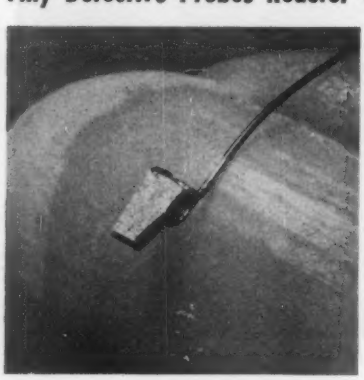
Four reasons advanced for failure of the field checkout were: 1. Unavailability of sufficient skilled service personnel. 2. Failures due to errors of service personnel. 3. Failures of service equipment. 4. Failures due to servicing provisions.

In comparing the number of missiles hitting the target under "field maintenance" and "no field maintenance" philosophies, Ludwig said: "In addition to the larger number of operable missiles available (15 per cent in the example) . . . each operational component can be expected to be from 5 to 40 per cent cheaper due to omission of checkout provisions. By far the most important feature, however, is the cost of service equipment, service personnel, their field logistic support, and the logistic supply line.


Force Available With Field Maintenance
1000
Manufacture 1000 missiles (40 bad)
Factory check out
965
Field instal. check (10 bad)
945
Field combat inventory (2 bad)
Field check periodic (2)
930
Combat pre-launch check-out
890
Launch (1 bad)
Combat-effective missiles 829
Reject 30 bad 5 good
Reject 8 bad 7 good 5 damaged
Reject 1 bad 7 good 5 damaged 2 worn-out
Reject 0 bad 20 good 10 damaged 10 worn-out
Failures 1 bad 30 GSE failure 20 GSE false-failure 10 airborne GSE
Force Available Without Field Maintenance
1000
Manufacture 1000 missiles (40 bad)
Factory check out
965
Launch (10 bad)
Combat-effective missiles 955
Reject 30 bad 5 good
Failures 10 bad

Errors and accidents during field checkout of missiles exact a severe toll on the number reaching a launching site. Fates of two identical batches of 1000 missiles—with and without field checkout—are shown in this hypothetical example. Field maintenance philosophy (top), while reducing misfires to one, reduces combat-effective force to 829 missiles. No-maintenance procedure, which accepts possibility of 10 misfires, puts 955 missiles on target.

Tiny Detective Probes Reactor Cores



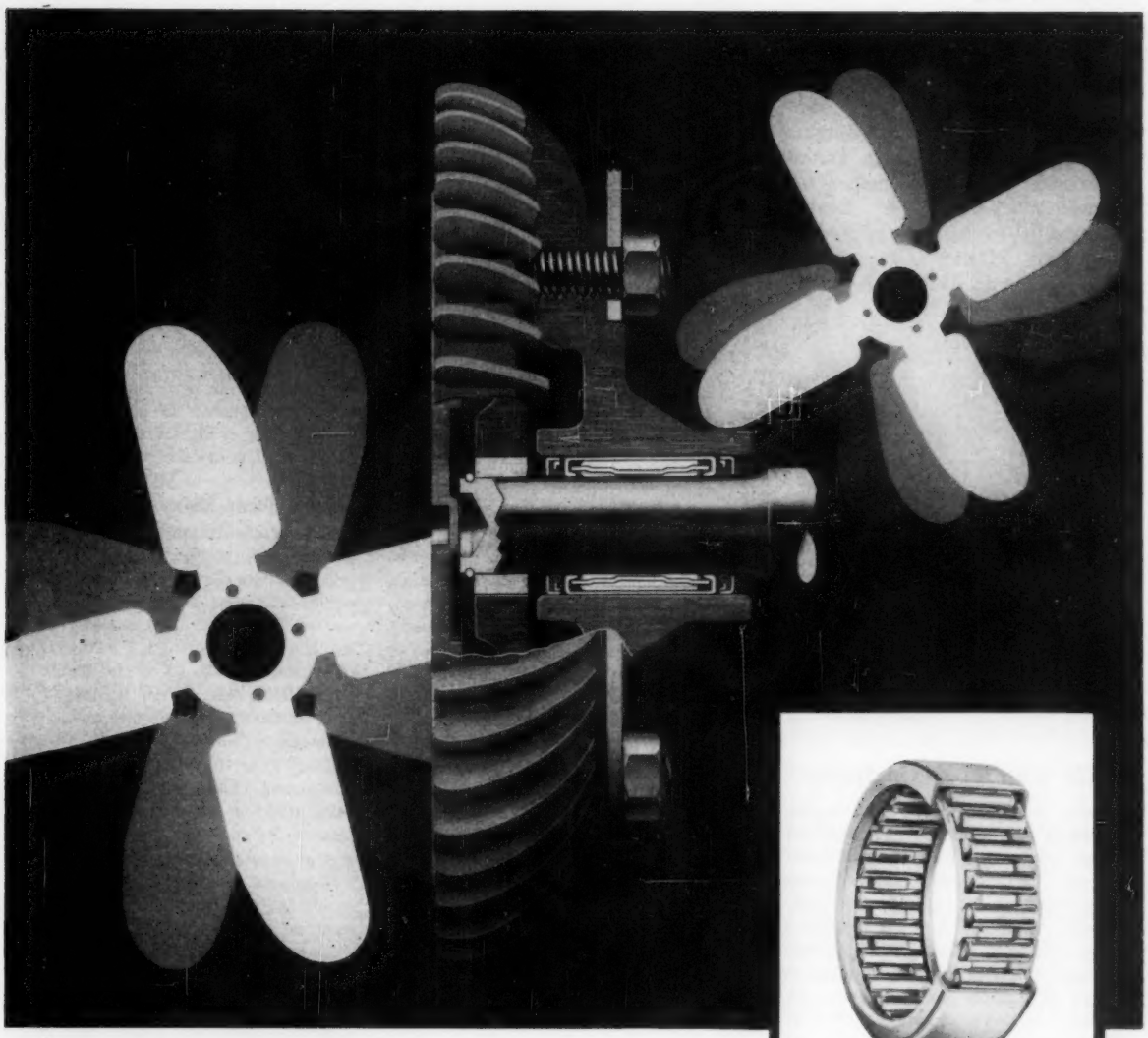
A pinhead-size neutron detector is leading the way to improved reactor design by giving atomic scientists their first detailed maps of reactor neutron-flux patterns. Developed by Westinghouse, the tiny neutron spy can "look" into tight, out-of-the-way spots, such as in the spaces between close-fitting fuel plates in reactor cores. Designed to ignore fast neutrons and gamma rays, the detector consists of a tiny piece of germanium or silicon, covered with a millionth of an ounce deposit of U-235. Splitting of the uranium atoms by neutrons generates electrical pulses

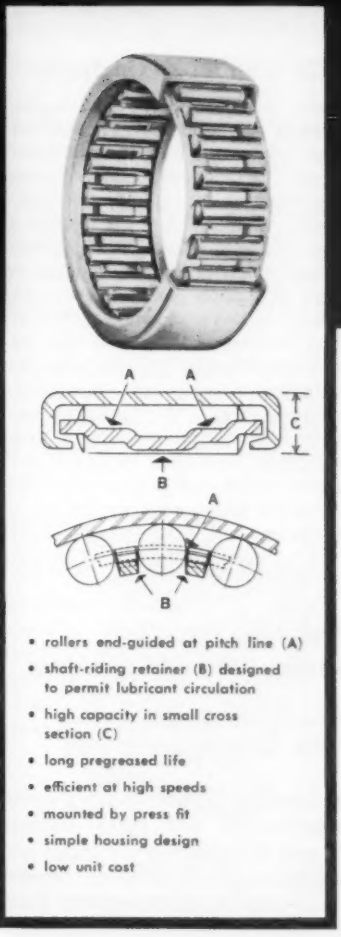
Lead-Treated Fabric Damps Low-Frequency Sound Waves

Coating Adds Mass Without Stiffening

MOBILE, ALA.—Cotton or glass-fiber cloth coated with B. F. Goodrich's Geon polyvinyl resins containing lead powder damps out low-frequency sound waves on which most acoustical material has little effect. The secret is in the added mass supplied by the lead.

Goodrich claims the plastic has





- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Schwitzer Variable Speed Fan Drive features new Torrington Bearing for economy, stability, lifetime lubrication

The original design of the Schwitzer Fan Drive, used in passenger automobiles to reduce fan horsepower and noise, called for two ball bearings. By replacing these with one Torrington Drawn Cup Roller Bearing, Schwitzer engineers have simplified the design and reduced costs.

This unique bearing firmly supports the drive housing and fan so they run true despite possible couple loads due to gyroscopic action. Ample lubricant reserve capacity permits pre-lubrication for the life of the fan drive.

Many new opportunities for economy, design simplification and operating improvements are opened up to engineers and designers by the new Torrington Drawn Cup Roller Bearing. Services of Torrington's engineering staff are offered to help you with product development work. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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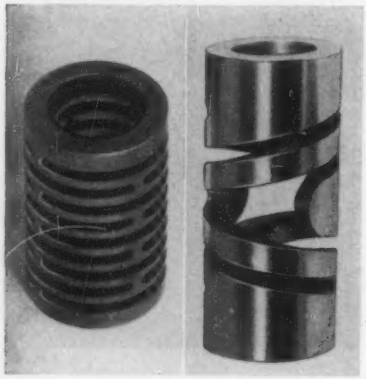
Circle 410 on Page 19

the exceptional flexibility necessary for installation in jet airliners where the material is scheduled to be first used. Other suggested applications include x-ray protection in clinics and hospitals and sound dampers for business machines. The treated fabric, called Coustifab is a product of Mobile Plastics Div., Cordo Chemical Corp., Mobile, Ala.



No Tilt with Machined Springs

Dynamic stability of an unusual degree is offered by machined compression springs developed by Consolidated Controls Corp., Bethel, Conn. Loads are transmitted through symmetrically located, axially opposed loading points, eliminating spring buckling and rotation. Effective coil length does not change with load as it does in conventional helical wire springs. The resulting constant spring rate can be closely controlled by grinding after the basic shape is machined. Parallelism of bearing faces and free length can also be held to close tolerances. Two basic shapes have been produced, herringbone (right) and gimbal (left). The herringbone spring occupies less space than an equivalent gimbal type.

Billion-Mile Space Talk Possible with New Techniques

Low-Power Signals Compete With Static From the Stars

Los Angeles — Maintaining radio communication with space vehicles that may travel billions of miles out in space has posed one of the toughest questions in space research. First and foremost, radio equipment carried aboard satellites and future space probes has to be ridiculously small in comparison to performance demands. The critical factor, of course, is weight—by accepted rule of thumb, 1 lb of orbiting or escape payload requires 1000 lb of launch vehicle.

However, like many other "impossibles" that have recently been surmounted, the communications problem seems to have been cracked. Army's Jet Propulsion Lab designed a 2-lb transmitter with a range of some 225,000 mi for the recent Pioneer III space probe. Key to the transmitter's tremendous range is the new Microlock concept incorporated in ground receiving and tracking circuitry.

In communicating with a satellite or space vehicle 225,000 miles from earth, the noise in space and the power needed to send a signal are the primary considerations. Since power is, in this instance, synonymous with weight, a big job in the development of a space-communications system was to eliminate or overcome noise and thus allow use of low-powered signals.

"Noise" can be identified as static created by cosmic rays, radiations from stars and planets, electrical movement within the ionosphere and troposphere, the free-flowing electrons in earthside radio or electrical equipment, and even by "hot" electrons within the radio receiving equipment itself. The problem of receiving a faint signal in the presence of noise is familiar to anyone who has attempted to listen to a radio program from a distant station during a thunderstorm.

The underlying principle of Mi-

Anybody Need a Gravitational Reciprocator?

Humor and the gentle art of spoofing are infrequent visitors in the multisyllabic world of technical exposition . . . a world where "style" leans heavily toward the compound noun and the piled-up adjective. You may get a chuckle out of these two "new product items" sent to us by the technical publicity agency, Harry W. Smith Inc. The "stories" are said to be part of a surplus stock that's been filtering into the Smith office by "heliograph from Tashkent, by dhow from Hejaz, and by courier from Ives." We suspect a bit of holiday horseplay.

New Gravitational Reciprocator Stimulates Automated Plant Life

Gravitational reciprocator provides handy time and motion (dis)integrator for signal watchers in automated plants. Device consists of two semispheroids conjoined by a short common axis, and is controlled by a three-foot length of multifilament winding or unwinding, as the case may be. (The more advanced cases may be fully unwound.) Operation is based on the first law of conservation of energy, "Let George Do It," as modified by the first law of fluid mechanics, "Perpetual Effervescence." Developed at the Army's hush-hush Crossbow and Catapult Arsenal, the reciprocator is the first publicly announced achievement of the top-secret Project YOYO, which has since been hastily reclassified. A manual model, designed for installation on the middle digit of a prehensile manipulator, is energized by a unique bicep-flexor self-winding linkage. For fully automated plants having no personnel, a motorized model is available. Serious researchers desiring more comprehensive detail may obtain a 420-page technical manual through request on competitive publisher's letterhead.

Miracle Fiber Shows Promise

Feature article discusses properties and possible applications for new miracle cellulosic fiber derived from herbaceous plants. Can be sawed, drilled, and worked like plastic. Has excellent tensile and flexural strength. Is buoyant in aqueous media. Can be painted with relative ease. When ignited, sustains exothermic reaction and gradually disintegrates into glowing fragments conducive to food preparation and group song. Thick sections may have some utility in construction. When fibers are degraded and dried from a watery pulp, resultant film can be utilized for applications in reading, writing, and wrapping. Article is frankly wistful, since no real market appears to exist. Text, embossed on three 4' x 8' thermoplastic sheets, will be shipped fob New York. Cannot be folded.

crolock is a technique known as "phase coherent detection," or application of a "phase lock loop." When a signal arrives from the space probe's transmitter, a duplicate signal is generated within the receiving equipment and the two are synchronized, or locked in phase. In this manner, the low-level beacon signal itself, and not both the signal and the noise are recorded.

Upon arriving at the Microlock station, the space-probe's signal has only 10^{-20} the amount of power required to illuminate an ordinary 25-w bulb. Conversely, if the light from a 25-w bulb was radiated with the Microlock system it could be "seen" from a distance of 4,000,000 miles.

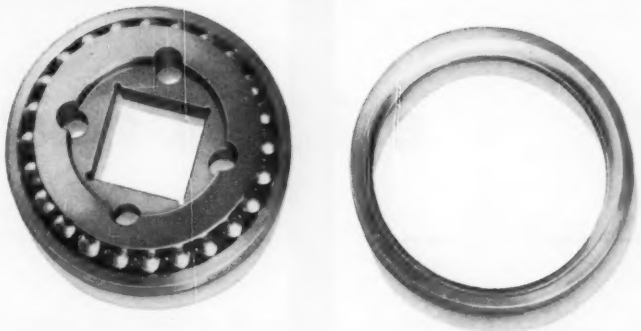
Through use of Microlock and with modification in existing antennas and pre-amplifiers, it is presently possible to communicate with space probes sent to Mars or Venus

Equipment utilizing the Microlock technique is being built for the various military services and space agencies by Hallamore Electronics Div., Siegler Corp., Anaheim, Calif.

Honeycomb Repair Kit

Damaged honeycomb panels on aircraft are repaired in the field with a portable patcher. The new tool consists of a self-sealing vacuum diaphragm, vacuum aspirator, and heat source in a single molded rubber unit. It applies 6-in. fiber-glass patches to aluminum panels. Boeing Airplane Co. built the device.

Square-Hole Ball Bearing Simplifies Antenna Design



This radar bearing, 1.500" OD, carries 3000 lb. thrust while turning through 180° at 90 oscillations per minute. The split outer race permits larger ball complement and increased load capacity.

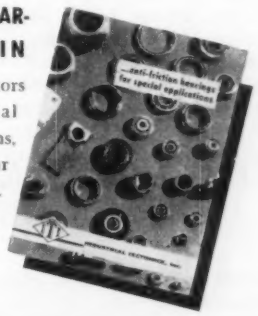
In planning the mechanical design of a radar antenna, the designer found that by using a ball bearing with a square hole, he could avoid limitations imposed by standard bearings. To bring this dream to reality, he had Industrial Tectonics design and produce the special bearing shown above. This has resulted in (1) a simpler and less costly design of the assembly that the bearing carries, and (2) a stronger and more rigid support.

In this and many other ways, the availability of ITI special bearings permits new freedom of design, and new economy. Remember —

IF YOU need anti-friction bearings of *special shape, size, heat resistance, corrosion resistance, low torque, ultra precision, non-magnetic properties, or other unusual characteristics,* we can supply them — designed and built to your specific requirements. We invite your inquiries.

NEW 24-PAGE BEARINGS BULLETIN

tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*



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WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

The Human Eye, Nature's inspiration for the camera, can convert wavelengths of blue-green light measuring as little as 400 microns into visual perceptions that are truly life-size. Yet this entire human mechanism occupies space less than 1″ in diameter.

Tiny New Potentiometer, shown actual size, is designed to add space-saving precision to missile and aircraft servo mechanisms. Two MPB bearings in it assure accurate, low-torque shaft rotation — a vitally important benefit in sub-miniature components.

Man With Miracles. This is Maurice Hebert, one of MPB's Sales Engineers. He'll personally help you choose the correct MPB bearing to reduce friction and increase the precision of your instruments — while keeping your operating costs low with trouble-free service.

Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN POTENTIOMETER SHOWN ABOVE

The Smaller The Better is often completely true. Engineers now know that miniaturization is the surest method of developing new or improved components for many of the latest developments in modern industry. But, as components become smaller, the problems of maintaining high precision and long service life become larger — and the call for MPB bearings constantly increases. MPB answers with the most experienced engineers in the miniature bearing industry, and advanced research facilities . . . producing over 500 types and sizes of bearings from ⅜″ O.D. down, with specials as required. We welcome your request for engineering advice, our catalog, or both.

Write Miniature Precision Bearings, Inc., 112 Precision Park, Keene, N.H.

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EXTRAORDINARY BEARING PROBLEMS?

"REALI-SLIM" BALL BEARINGS

Ball radial | Angular contact | 4-pt. contact

Cross sections from ¼" to 1" and 4" to 40" bore diameters. Some sizes available from stock.

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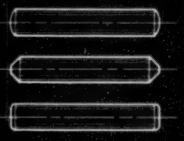
Type KN

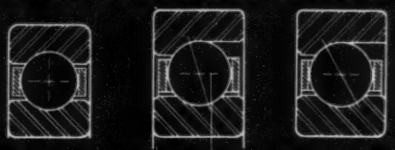
Standard sizes — in stock

NEEDLE ROLLERS



Spherical, conical or flat-end types

RADIAL BALL BEARINGS

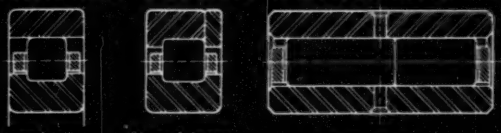


Conrad design, types LC, HC and BLC

Maximum capacity design, types HM, BLM

Angular contact design, types HA, BLA

RADIAL ROLLER BEARINGS

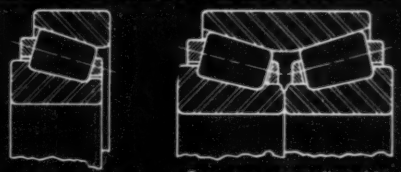


Lipped inner, straight outer race types RN, RX and RNW

Lipped inner, one lip outer, side ring type RP

Straight inner, straight outer, mill type RM

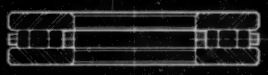
TAPER ROLLER BEARINGS



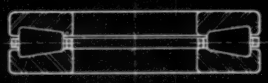
Single row type TS

Two row, non-adjustable type TNA

THRUST ROLLER BEARINGS

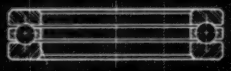


Straight roller, flat races, type RT

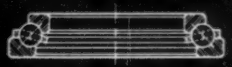


Conical roller type RTC

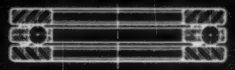
THRUST BALL BEARINGS



Grooved race type BT



Angular contact type BTA



Flat race type BTE

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Circle 413 on Page 19

MEMO

To: Management

From: Engineers

Subject:

How to "sponsor" a

MANY COMPANIES are already helping engineering unions to help themselves, if engineers' replies to a recent MACHINE DESIGN survey are any indication.

Engineers as a group don't show much affection for unions. But they can spell out, in vociferous detail, the conditions causing engineers or scientists to join unions. And most of their reasons are aimed straight at management.

Thumbs Down: Unions or collective bargaining associations for engineers get an unfavorable reaction from almost three-quarters of the engineers reporting. Nonbargaining, within-plant associations (e.g., sounding-board groups) look a lot better to engineers: 36 per cent favorable, 34 per cent unfavorable, 30 per cent neutral.

Engineers already represented by unions are the only group really happy with unions. Except for this one group, reactions of engineers in small departments and large departments, supervisors and nonsupervisors, registered professional engineers and those not registered, are surprisingly similar. The slight differences between groups are just about what one would expect.

Money Is the Root: Why do engineers join unions? Some 18 different reasons were listed. Of these, money led the parade—low salaries or wages, poor salary administration, lack of compensation for overtime, and so on.

The second biggest condition favoring unionism is a sour engineer-management relationship — lack of recognition, little appreciation or consideration, compounded with indifference. Engineers seem to get fewer pats on the back than the family pooch—so they don't react like management's best friend.

Engineering Vacuum: The question, "to join or not to join," seems to be a choice between negatives. Engineers don't like unions; but they also don't like today's engineering climate.

Of the 18 conditions listed, the 13 checked are completely or partially controllable by management. These 13 are all negative—"lack of" recognition, security, communication; "poor" management, working conditions; "inadequate" advancement; and so on. In effect, engineers say that their employers create a vacuum which the pressures of unionism could fill.

Unions do create some positive pressure to fill this vacuum—"union gains" account for 4 per cent of the total reasons listed. This could be interpreted as the extent to which unions have sold themselves; as a matter of interest, this is the only "positive" group of answers in the whole survey.

Ouch!: The engineers surveyed also draw a caustic caricature of their brethren who are sympathetic to unions. The union-inclined engineer is pictured as a lazy (Reason No. 13), mediocre (No. 6) performer, who can't stand on his own two feet (No. 18) but who is never satisfied (No. 15).

Obviously, this view is emotionally "loaded" and not the result of calm, objective analysis in which engineers are supposed to excel. However, it suggests that engineers have a tremendous emotional leaning toward "rugged individualism" —and also that perhaps this tendency is the engineering union's biggest problem in selling itself. — R. L. STEDFELD

union

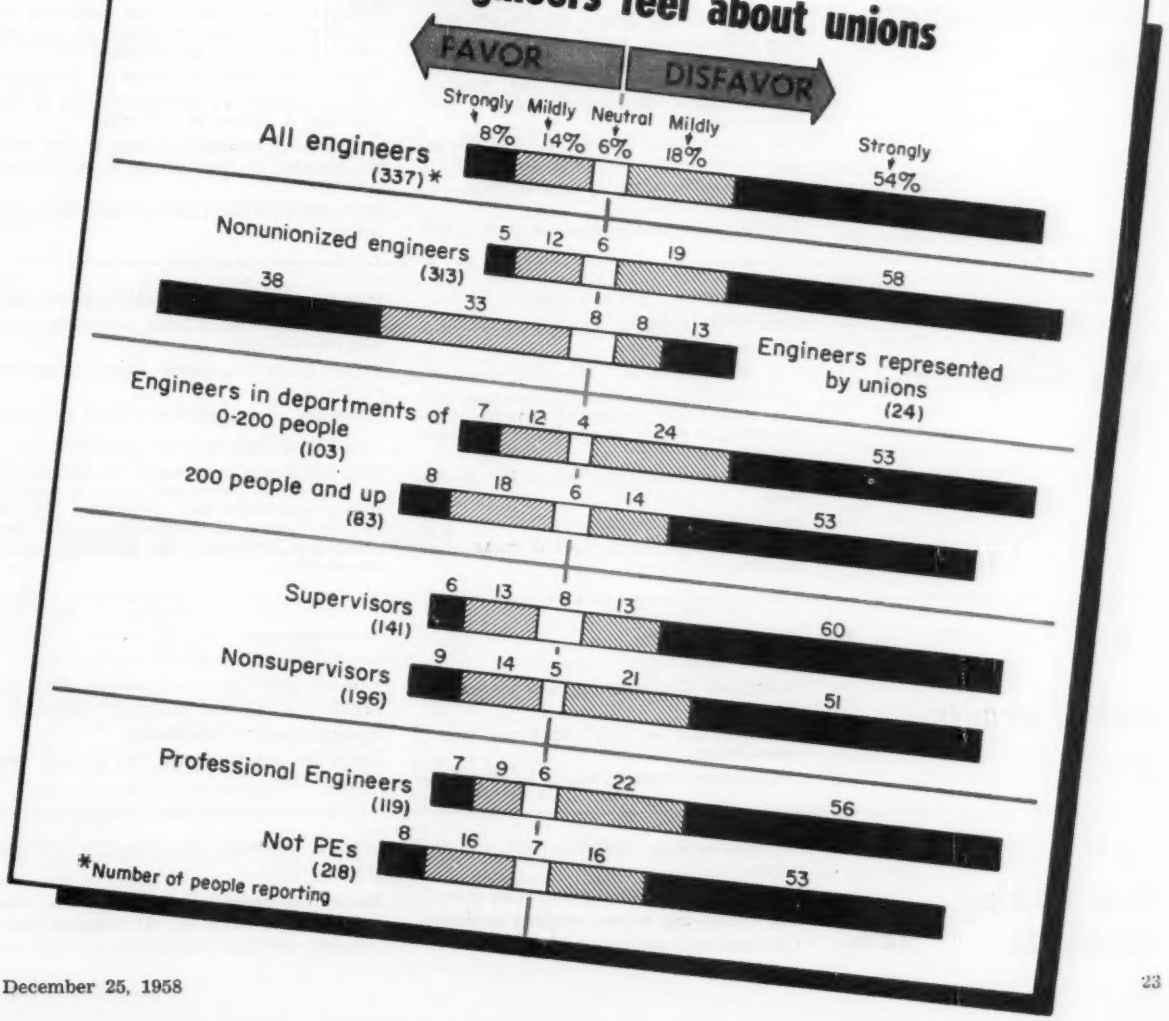
Survey Details

Questionnaires were mailed on September 22, 1958, to 1000 engineers carefully stratified by industry and geographical location, using MACHINE DESIGN census figures as a universe. Only supervisors and "working engineers" were included in the sample, but a qualifying question was asked to screen out other job classifications. Sample was also selected to emphasize larger engineering departments.

Of the 405 returns, 337 were used, and 68 not used. Reasons for elimination: 28 late, 29 self-classified as "management" or "employer"; 2 self-classified as "draftsman or technician"; 9 incomplete.

This article is based on responses to three questions: 1. "How do you feel about unions or collective bargaining associations for engineers and scientists?" Check-off choices were "strongly favor, mildly favor, neutral, mildly disfavor, strongly disfavor." 2. A similar question on "nonbargaining within-plant associations (i.e., sounding-board groups)." 3. "What conditions do you think cause engineers or scientists to join unions?"

How engineers feel about unions



MANAGEMENT

Check these reasons!

Why engineers join unions

The question: What conditions cause engineers or scientists to join unions?

Here's what they say—

1 ✓ Money (23%)*

"Low salaries.

Small salaries and/or inadequate fringe benefits.

Unequal salary conditions.

Employers refuse to pay salaries in keeping with the education and experience required to do these jobs as compared to low-skilled workers' pay.

Unsatisfactory wage and salary administration programs.

Lack of regular increases.

Poor and nonrising pay scales.

Pay incommensurate with contribution to business.

Inadequate salary treatment relative to other groups within the same company.

Unrealistic salary schedules compared to equivalent industries.

Low pay, especially for older engineers in comparison to starting rates of new graduate engineers and skilled workers such as plumbers, electricians, bricklayers, etc.

Inadequate and inconsistent management salary procedures.

Required or expected overtime without compensation.

Wage structure based too much on group, too little on individual merit.

Poor review and wage policies. Wage reviews or merit increases must also cover cost of living.

*Based on total of 664 individual reasons given by 337 engineers.

2 ✓ Lack of recognition (12%)

"Lack of consideration by management.

Company does not appreciate the fact that without engineering there would be no product.

Nonrecognition of talents by the company.

Poor understanding by management.

Continued indifference toward problems of the engineer—both personal and monetary—which makes union membership the lesser of two evils.

The engineer feels that his services are not appreciated equally to those of production.

Lack of appreciation by management, i.e., prestige and wages.

Working in huge organizations often results in a lack of recognition. The practice of placing many nonprofessional, less-qualified people at the same status level as the engineer's contributes to this lack of recognition.

Inadequate recognition for job performed in comparing importance of design to, say, an assembly hand on the pay-scale level.

Disregard of individual needs of engineers.

Lack of concern by management for giving engineers a "sense of belonging."

Management misunderstanding of the role the engineer or scientist has in present-day business.

Personnel department lack of appreciation for technical people.

3 ✓ Poor management (8%)

"Poor engineering administration.

Managerial failure to reward performance.

Very poor supervision.

Poor foresight on the part of management.

Administration of engineering-personnel policies by personnel department unaware or uninterested in particular problems of engineers and scientists.

Management's inept method of job description.

Inefficient merit systems.

Inadequate supervision. Lack of management planning.

Poor personnel policies of some organizations.

Square pegs in round holes need someone to take care of them.

Biggest factor is a poorly chosen immediate supervisor.

Delegation of responsibility without authority.

Poor use of their skills by companies.

Poor selection of supervisors. The elevation of an unqualified person will make it mandatory to take orders from an inferior. This is the chief cause of dissatisfaction, and dissatisfaction is the only real reason for union membership.

4 ✓ Lack of security (7%)

"Personal insecurity.

Lack of job security.

Protect self from unemployment by seniority controls.

Trying to find an "old folks home" type of organization.

Job insecurity based on fear of being replaced by younger men.

General security trend.

Frequent layoffs or poorly defined function.

Arbitrary layoffs and placement policies.

Insecurity due to immaturity.

Desire for security in the face of their own incompetence.

5 ✓ Poor working conditions (5%)

"To better working conditions with organized groups.

Hope to improve working conditions (hours).

Low morale due to poor working conditions.

Unsatisfactory working conditions.

Working conditions not compatible with engineering work.

Harsh and severe working conditions and lack of appreciation by old-fashioned management.

6 **Lack of ability** (5%)

" Lack of ability to advance on his own merits.
Incompetence to do the job required.
Only way poorer engineers can gain any recognition.
Individual incompetence.
Subpar personnel clamoring for raises.
Job insurance for a mediocre performer.
Fear of their own inabilities becoming revealed and hence fear of job.
Not having enough ability to get ahead alone.
Unqualified people hoping for recognition by card.
Excessive emphasis on salary by unqualified or mediocre individuals.
Inability to make good on their own.

---

7 **Not treated like professional** (5%)

" Subprofessional treatment by employers.
Companies failure to treat same as professional people.
Lack of professional recognition.
Handling of engineers without regard to professional status.
They are not treated as professionals, nor paid as well.
Being handled as if just another person with no recognition of professional standing, although the company wants the engineer to act like a professional toward the company.
Management's inconsiderate attitude toward an engineer's professional status.
Refusal of management to recognize the engineer as a professional man and accord him the type of treatment associated therewith.

---

8 **Inadequate advancement** (4%)

". Passed up on promotions.
Unwillingness of companies to promote engineers.
Unsatisfactory promotional policies.
Poor advancement opportunities.
Companies that overlook ability and initiative in promotions.
Tendency of many companies to advance accountants, salesmen, etc., but not engineering personnel.
Slow promotions.

---

9 **Union gains** (4%)

" More power to bargain.
Union appeals may be strong and professional appeals may not exist.
Observation of gains made by labor unions and trade unions.
Lack of ability to bargain for themselves.
Since most engineers are introverts and slow of speech, they need a union to talk for them.
The high wages won by unionized labor.
A realization that the profession is unrepresented.
Increased unionization of employees in other than engineering work.
Granting benefits to unionized shop without compensating benefits to nonunionized engineers.
Idea that unions can obtain more benefits—numbers mean power.

---

10 **Loss of individualism** (4%)

" Group engineering where individual expression is at a minimum. Production-line engineering.
Management which does not treat them as skilled workers, or individuals, but lumps them all together into one category and/or tries to "milk" them for all they can.
Company policies which do not allow for the man who is above average.
Large engineering departments where work becomes routine.
Large organizations where engineers tend to lose individuality.
Large groups of engineers resulting in impersonal supervision.
Management regiments engineers when they are in large groups.
Mostly the largeness of the engineering department. Small groups have no need for unions. "

. . . and 8 more reasons

11. **Lack of communication (3%)**—poor management-engineer communication; no opportunity to air grievances; lack of engineer-supervisor contact.

12. **Company abuses (2%)**—exploitation by management; mistreatment; injuries.

13. **Lack of initiative (2%)**—no ambition; lack of interest for personal improvement; engineers too lazy; desire to progress without effort.

14. **Assignment to subprofessional work (2%)**—poor utilization of engineers and scientists; used as technicians, "errand boys"; stockpiling of talent.

15. **The "green grass" complex (2%)**—"What have I got to lose" or "green grass on the other side of the fence" attitude; expecting something for nothing; "free ride."

16. **Status, prestige problems (1%)**—lack of prestige or attempt to gain prestige.

17. **No voice in management (1%)**—not included in management group; no chance for product or policy decisions.

18. **Lack of self-confidence (1%)**—lack of faith in ability; inability to stand on own two feet.

Miscellaneous (9%)—individual reasons less than 1 per cent of total.

Solar Roof Plus Heat Pump Heats or Cools Ranch House

Peak Loads Smoothed By 4400 Gal Reservoir

NEW YORK—The sun gets a cloudy-day boost from an auxiliary heat pump to warm an experimental solar house built by the University of Arizona's Institute of Atmospheric Physics. The pump also lends a hand to cool the house during extra-hot summer days.

Resulting from one of the most ambitious attacks on residential solar-heating problems to date, the system points the way toward commercially sound solar heating and cooling in five years, say developers.

Diagrams show how the thin copper roof—holding multiple tubes for water circulation—serves alternately as a heat collector in winter, heat rejector during summer nights. Similar water-tube panels, located on the inside ceilings of the house, radiate heat to rooms in the winter, absorb heat in the summer. Thermal storage for the system is a 4400 gal water tank.

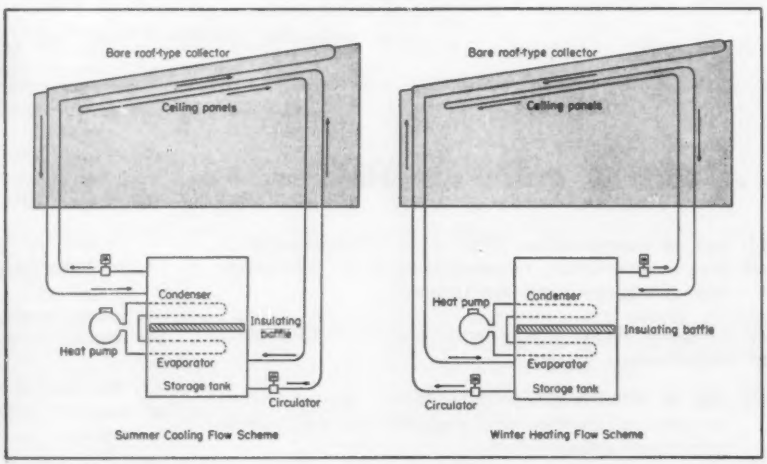
During cold spells, water heated by the roof-top collector is pumped to the bottom of the tank, rises to the top, and is circulated through the interior ceiling panels. If the solar collector should fall behind in its water-heating job during long cloudy spells, the auxiliary heat pump redistributes heat from the bottom of the tank to the top.

Besides making the most of existing heat in the storage tank, the heat pump actually increases efficiency of the solar collector by lowering temperature of water pumped to the roof.

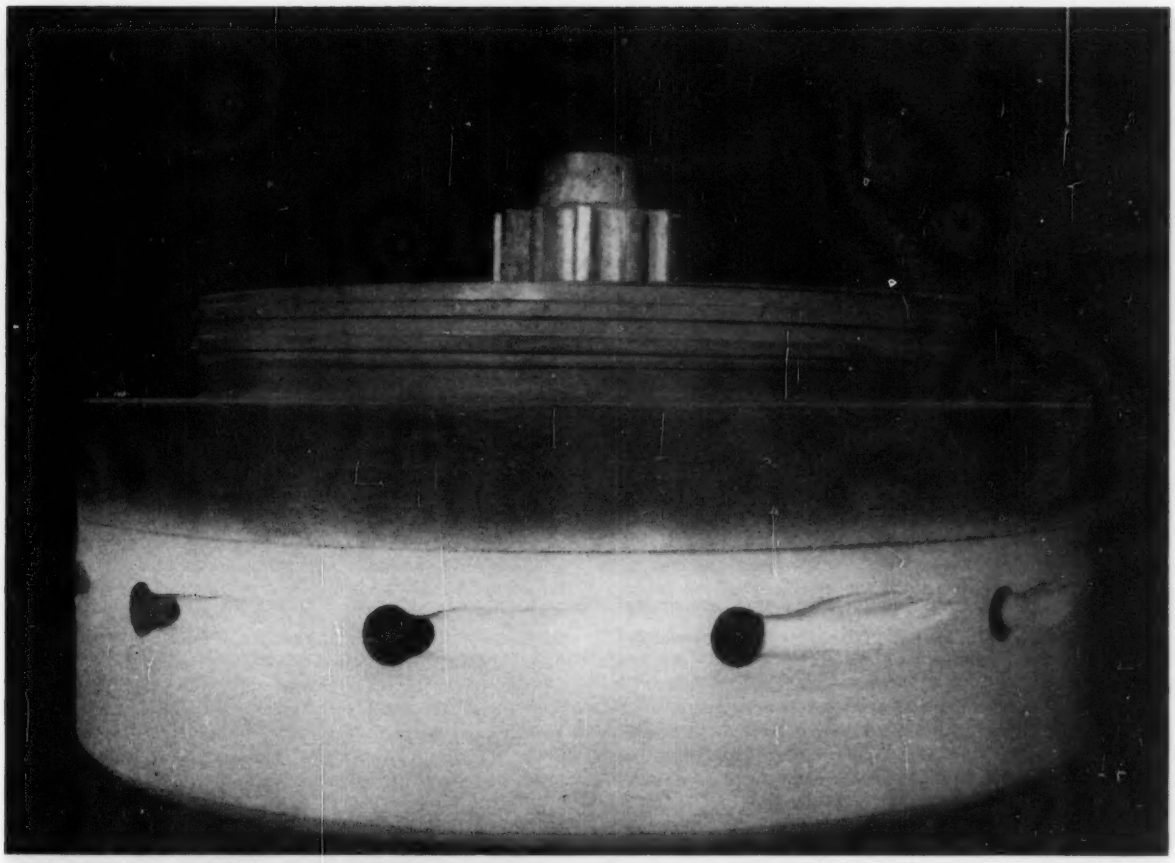
During hot days, functions of roof-top and ceiling panels reverse. Heat absorbed by interior panels heats water circulated to the water tank. The roof panel—now a heat rejector—is operated nightly to dissipate heat to the cool night air. If the weather is unusually hot, the heat pump again operates to increase water temperature at the top of the tank, lower it at the bottom.

Portable Island

A 1000-ton oil-drilling rig, built by R. G. LeTourneau, will be towed across the Atlantic Ocean for delivery to the Italian Government. The triangular platform is mounted on three 120-ft legs and can be raised or lowered by electric motors at the rate of 1 ft per min. Tank-like feet provide stable footing on the sea floor. If rough weather is encountered during the overseas trip, the legs will be lowered full depth to serve as an effective keel.



Solar roof, made of thin copper panels, has integral tubes connecting headers at ridge and eaves. Water pumped through the tubes during cold weather is heated by the sun and returned to the storage tank. Circulated through ceiling panels, the hot water heats the house. For summer cooling, water from the tank is piped to the roof panels where it is cooled by radiation and convection to the night air. During peak-load periods, the heat pump aids the roof-top collector/rejector by transferring heat from bottom to top of the "thermal-storage" tank.



The Georgia Kaolin Company, well-known manufacturer of industrial clays, reports that they have made substantial savings by coating worn separator centrifuge bowls with Norton ROKIDE "A" coating. Worn bowls were previously returned to their manufacturer after six to eight months of high speed service for restoring to their original condition. But now Georgia Kaolin applies ROKIDE "A" coating before the bowls become badly worn . . . and at a fraction of repair cost at the factory. Service life is greatly extended. Maintenance costs and down time are substantially reduced.

How ROKIDE* Coatings increase service life, cut maintenance costs of moving parts

ROKIDE coatings are applied by heating the end of a ceramic rod and projecting the molten particles at high velocity. Reaching a prepared surface, they adhere and solidify. Protecting parts of a wide variety of sizes and shapes, these coatings are in extensive, rapidly increasing use in military and general industrial applications.

Three types of ROKIDE spray coatings — "A" aluminum oxide, "ZS" zirconium silicate and "Z" zirconium oxide — are hard, adherent, crystalline refractory materials. Parts, particularly metals, on which these coatings are especially useful are those requiring thermal or electrical insulation . . . resistance to wear or corrosion . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness.

Possible applications: bearing surfaces, metal rolls, feed rolls, nozzles, pump shafts, thermocouple tubes and wire, mechanical seals, extrusion dies, laboratory molybdenum boats, vibratory feed hoppers, metal guides, metal melting pots, sanding fixtures, induction heating coils, strain gages, and applications in the wire industry.

Norton maintains facilities for applying ROKIDE coatings at Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, California. For further facts, write to NORTON COMPANY, New Products Department, 771 New Bond Street. Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

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NEW PRODUCTS

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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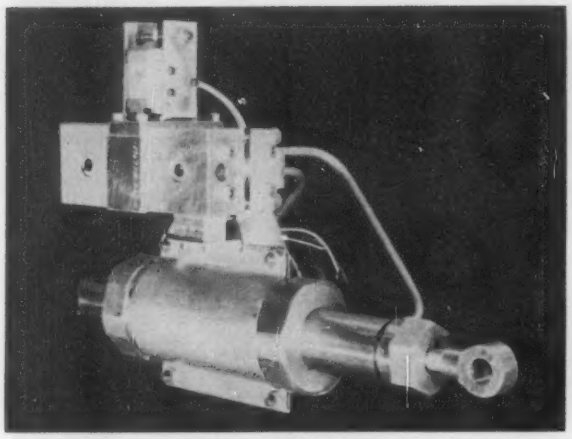


Gas Servo for Severe Service

Designed for use where extremes of heat, cold, or radiation are too severe for conventional hydraulic components, this force servo with position and velocity feedback operates on hot or cold gases. General Electric, developer of the servo, proposes its use in rocket nose cones, satellites, space gliders, re-entry vehicles, and aircraft that operate supersonically for long periods. Only three major components are involved—an energy source, valve actuators, and a stabilization network. When the unit operates on hot gas, a solid propellant is stored in a combination generator-accumulator. As a cold-gas servo, the system reduces radiation contamination problems in high nuclear-energy areas.

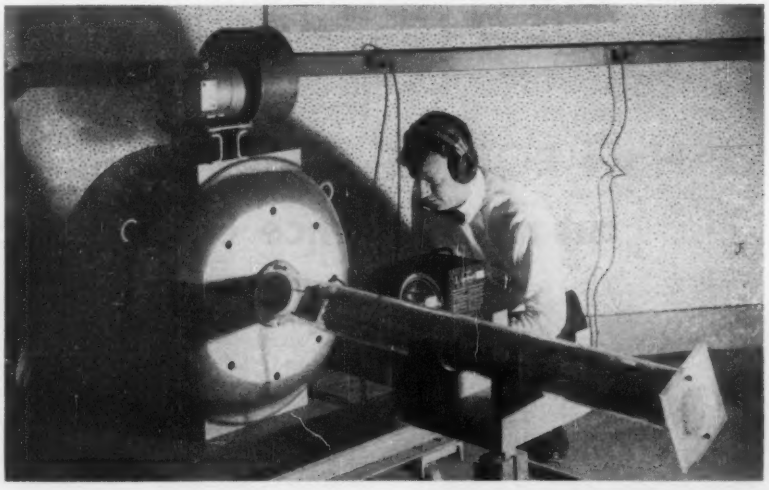
Vibrating Welder Joins Dissimilar Metals

Opposing rollers distort radially at 20 kc in this ultrasonic welder, forming a continuous seam between either like or unlike metals. The high-speed kneading motion of the wheels brings the metal lattices together to complete a perfect weld with minimum diffusion and distortion. The action breaks up oxide coatings, making previous surface preparation unnecessary. Magnetostrictive transducers furnish the vibration. Operating with 1000 w power, the welder can seam weld two 0.010 in. sheets of aluminum at 15 in. per minute. Welder is under development by Westinghouse Electric Corp., Pittsburgh, who claims the process avoids disadvantages of cold-weld technique for joining unlike metals.

Engineers Shun Active Politics

	Congressmen	Senators
Lawyers	234	65
Businessmen	100	15
Farmers	28	3
Educators	22	1
Doctors	4	0
Military	4	1
Engineers	2	2
Misc. unclassified	41	9
	435	96

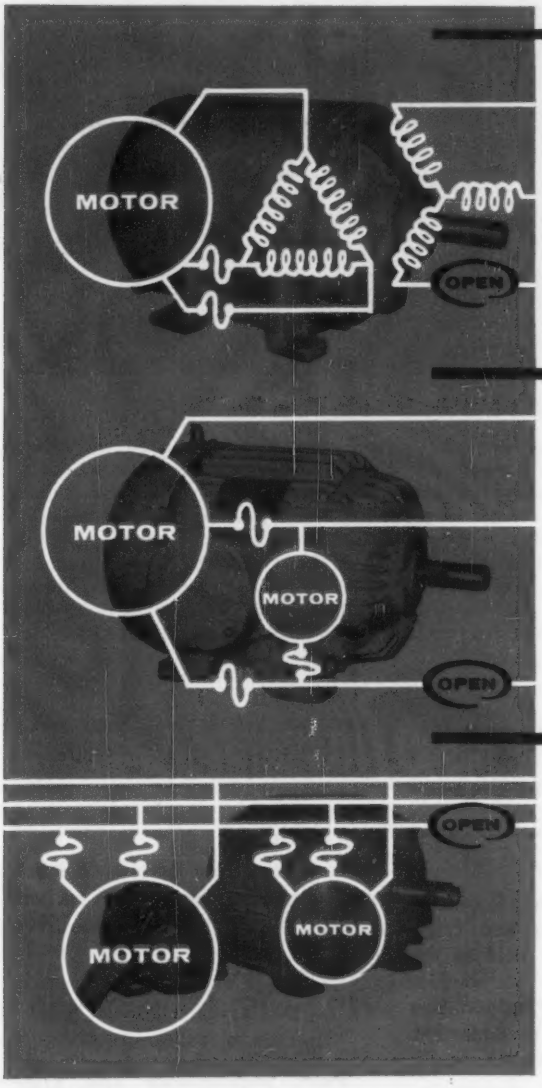
Only four engineers were among the 531 members of the last Congress. This is hardly an adequate proportion, considering the role of technology in our present society, says F. E. Wormser, vice president of St. Joseph Lead Co., and former assistant secretary in the Dept. of Interior. According to Mr. Wormser, it isn't necessary for large numbers of engineers to drop their present duties and jump into the political arena, but engineers should take a more active interest in the branch of government that is largely responsible for shaping the destiny of American industry. He suggests letters to congressmen as one simple, effective means of voicing opinion.



Noisemaker Tests Titan, Minuteman Nose-Cone Components

A cheap method of subjecting missile components to rocket-engine noise vibration is provided by this powerful electromechanical noisemaker. Unlike mechanical vibrations, which can be isolated by mounting shocks, acoustic vibrations pass through the surrounding air to jar components into an inoperative state. The noisemaker, built by Avco Research and Advanced Development Div., Crosley Corp., uses a loudspeaker with a 12-in. diam moving coil. It provides up to 166 db of random noise. Two testing procedures are used: 1. The generator is placed in a reverberant chamber, where noise reflects from the surfaces of the enclosure around the component under test, or 2. A progressive wave tube is used, as pictured above, in which noise is sent down the tube and absorbed at the end. In the latter method, the test specimen is placed between the generator and the absorbing material, and any angle of incidence can be specified.

Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs

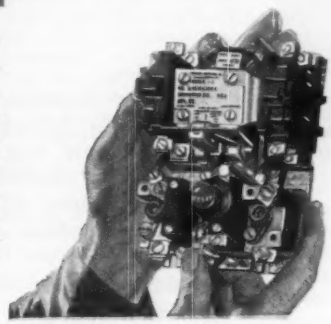


MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.

MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. For further information write Dept. Z-243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.



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Cutler-Hammer Inc., Milwaukee, Wis. *Division:* **Airborne Instruments Laboratory.** *Foreign:* **Cutler-Hammer International, C. A.**
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

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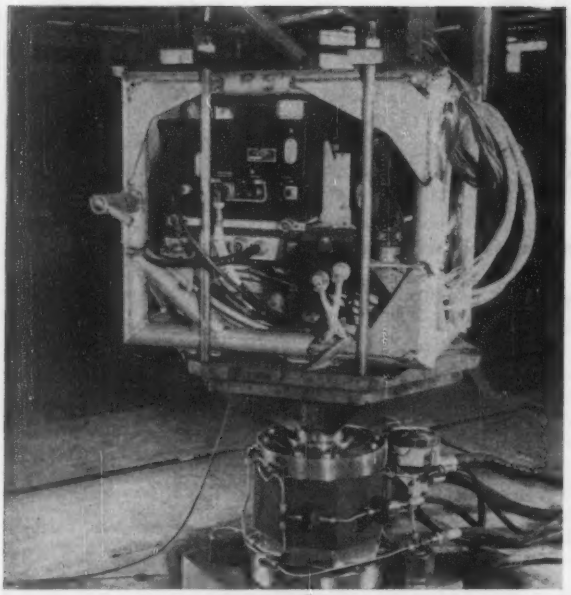
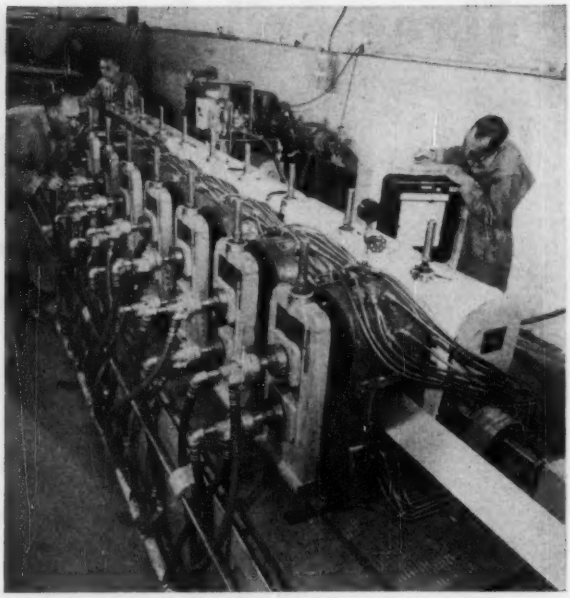


Fast Shake for High-Flying Parts

Ultra-high-force vibration testing of components for the upcoming F-108 interceptor, the Mach-3, B-70 chemical bomber, and the X-15 manned space probe, will be provided by a powerful electrodynamic shaker newly installed at North American Aviation's Engineering Research Lab. Built by Wylie Mfg. Co., El Segundo, Calif., the Hydrashaker has a blocked-force output of 24,000 lb at frequencies ranging to 2000 cps for simulation of vibrational stresses induced by powerplants and/or aerodynamic forces.



Oven-Hot Rolls Form Titanium

High-strength titanium alloy is being formed successfully on a modified Yoder Roll at Boeing Airplane Co. Enclosed heating—a Boeing-developed factory technique—is used to reach the required forming temperature of 1000 to 1600 F. Propane-fueled furnaces enclose each individual set of rolls, and roll shafts are hollow for water cooling of bearings. Tests have been conducted at rolling speeds of 1½ ft per min, but Boeing thinks speeds 12 to 15 times faster are feasible. Strip length has ranged to 32 ft.

Nylon Ship Propeller

Savings in weight and longer service life are two advantages claimed for nylon ship propellers. Dansk Thermoplastics Co., Denmark, cast the new propellers for fishing trawlers that operate in northern waters. The nylon propellers outlast bronze by a factor of two or three because they flex instead of bending when coming in contact with submerged ice and other obstacles. Nylon also shows better resistance to cavitation abrasion.

Meetings

AND EXPOSITIONS

Jan. 12-16—

Society of Automotive Engineers Inc. Annual Meeting and Engineering Display to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Jan. 21-23—

Southwest Electronic Exhibit to be held at the Arizona State Fairgrounds, Phoenix, Ariz. Additional information is available from exhibit headquarters, 4353 W. Missouri, Glendale, Ariz.

Jan. 26-27—

American Society of Lubrication Engineers. First Annual Gear Symposium to be held at the Morrison Hotel, Chicago. Further information can be obtained from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

Jan. 26-29—

Institute of the Aeronautical Sciences. Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 26-29—

Plant Maintenance and Engineering Show to be held at Public Auditorium, Cleveland. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

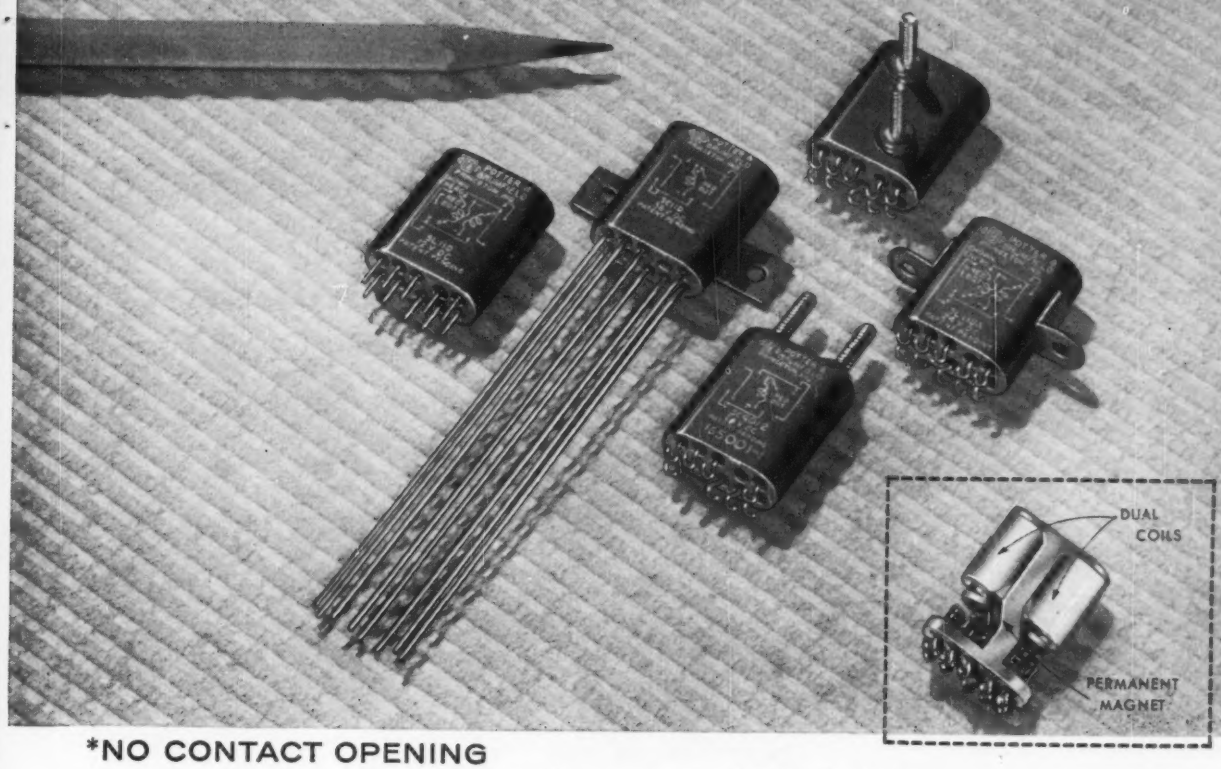
Feb. 3-5—

Society of the Plastics Industry Inc. Fourteenth Reinforced Plastics Conference to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

P&B MICRO-MINIATURE RELAYS LEAD IN

performance

SHOCK: 100g* VIBRATION: 30g to 2000 cps*

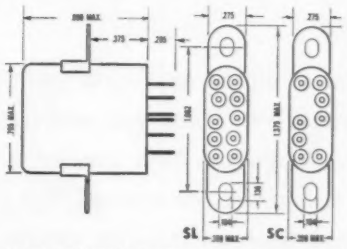


*NO CONTACT OPENING

New P&B crystal-case size relays, the SC and the SL (magnetic latching), show amazing shock and vibration capabilities. They absorb shocks of 100g and vibrations 30g to 2000 cps. without contact openings!

A highly efficient magnetic structure utilizing a permanent magnet makes possible at least twice the contact pressure found in DPDT relays of comparable size. One watt of power for three milliseconds operates either relay. Transfer time is unusually fast —0.5 milliseconds maximum.

For more information, contact your P&B sales engineer, or write Potter & Brumfield, Princeton, Indiana.



SL—dual coil latching relay. Operates on a 230 mw, 3 ms. pulse at 25° C. Permanent magnet latch locks the armature in either position.

SC—non-latching relay with series-connected dual coils. Operates on approximately 260 mw at 25° C. Coils must remain energized to hold the armature in the operate position.

SC and SL Series Engineering Data

GENERAL:
Insulation Resistance: 10,000 megohms, min.
Breakdown Voltage: 1,000 V. RMS.
Shock: 100g for 11ms.
Vibration: 30g 55 to 2000 cps.; 0.195" max. excursions from 10-55 cps.
Temperature Range: —65° C. to + 125° C.
Weight: 15 grams without mounting bracket.
Operate Time: 3 MS. max. with 550 ohm coil @ 24 V. DC. (SL: 630 ohm coil at 24 V. DC).
Transfer Time: 0.5 MS max.
Terminals: (1) Plug-in for microminiature receptacle of printed circuit board.
(2) Hook end solder for 2 #24 AWG wires.
(3) 3" flexible leads.
Enclosure: Hermetically sealed.

CONTACTS:
Arrangement: 2 Form C.
Load: 2 amps @ 28 V. DC, resistive; 1 amp @ 115 V. 60 cycles AC, resistive.
Pressure: SC—16 grams min.; SL—20 grams min.

COIL:
Power: SL—230 mw @ 25° C.
SC—260 mw @ 25° C.
Resistance: SL—10,000 ohms per coil max.
SC—20,000 ohms max.
Duty: Continuous.

MOUNTINGS:
Bracket, stud and plug-in.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

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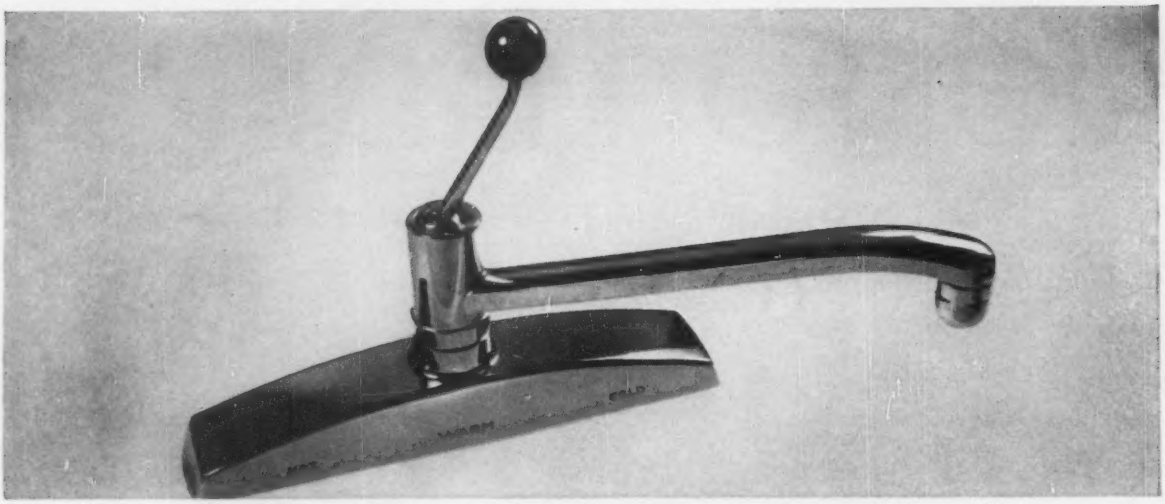
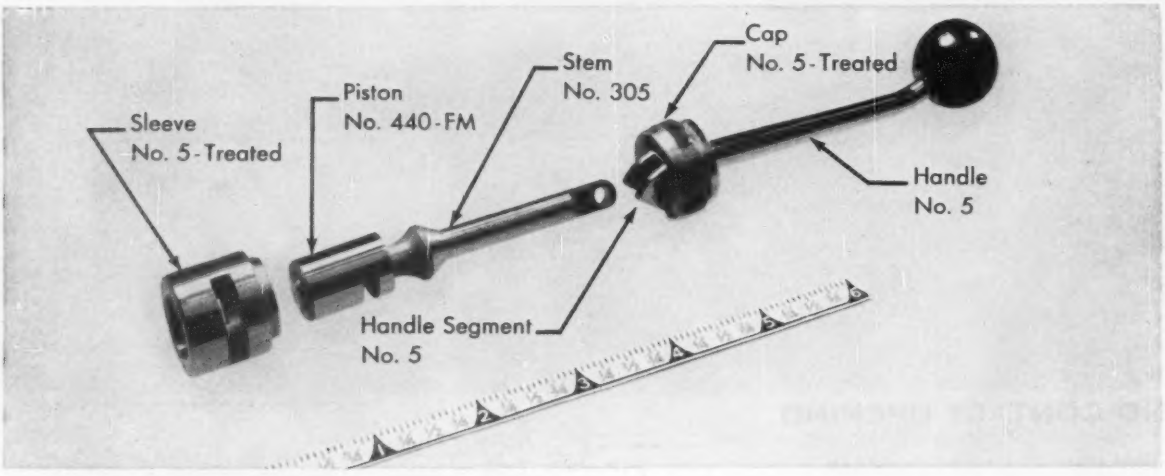


for strength, corrosion resistance and sales appeal

...it had to be Stainless



In this new one-handle mixing faucet all the important working parts are made of wear-resistant, corrosion-proof Carpenter stainless steels. Once you select stainless steel by Carpenter, you can forget about corrosion. You can design for high stresses, disregard maintenance problems, stop worrying about temperature variations and be assured that fabrication will be easy. And you not only get the help of consumer-acceptance of stainless products, but also the long experience of Carpenter. From the lab work through final production, Carpenter staffmen have the knowledge and the data. Call your Carpenter representative for the engineering information on stainless that you need. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

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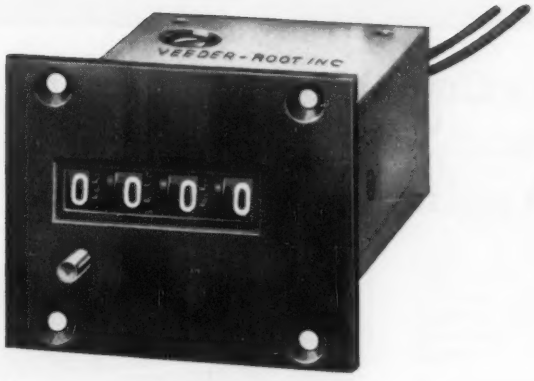

You told us to "tell all" about this ALL-NEW PANEL-MOUNTED HIGH SPEED ELECTRICAL COUNTER

You asked for it! Hundreds of requests for "complete specs" rolled in on the announcement of the 1591. So here they are . . . all on one sheet . . . for your counter file. And here's a quick review of the most newsworthy features of this all-new counter:

- Instant electric resetting.
- Push-button reset, either mechanically on the machine, or electrically from a distance.
- One button resets an entire panel.
- Panels can go right in your office.
- Counter is small, but figures are large.
- Speeds rated to 3,000 counts per minute.

ORDER NOW!

EVERYONE CAN COUNT ON

Veeder-Root

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Hartford 2, Connecticut

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For Your COUNTROL FILE

Complete Specifications ...Series 1591 Counter

•

Overall Dimensions: 2.1" wide, 1.7" high, 2.6" deep. Shipping weight approximately 1 lb.

Method of Counting: Actuated through electromagnets, these counters can be connected in series with any device having a contact arrangement. For optimum operation, 60% contact time is necessary.

Reset: Manual or electrical. Manual reset is accomplished by depressing the reset button extending through the front panel. Electrical reset is accomplished by energizing the resetting coil momentarily.

Size of Figures: .188" high.

Color of Figures: White on black.

Number of Figures: 4 or 6.

Speed: 3000 counts per minute is the maximum recommended.

Watt Consumption: Operating coil — 6 watts, reset coil — 15 watts.

Operating Voltage: 6, 12, 24, 48 & 115 volts DC are standard. For operation on AC power, suitable electrical components must be added externally to the counter.

Reset Voltage: 6, 12, 24, 48 & 115 volts DC are standard.

Voltage Variation Permissible: 10%, but not more than 10 volts.

Temperature Rise: 140°F under normal operating conditions when coils are left energized for long periods of time.

Lubrication: After every 30-million counts, lubricate per Veeder-Root service instructions V-78116-1.

Finish: Die-cast frame, with aluminum covers. Panel Plate dull instrument black.

NOTE: Any change in any of these Standard Specifications (above) makes the counter a Non-Standard item, produced to order only.

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

For further details on Crucible 56 and other comparative data, send the coupon.

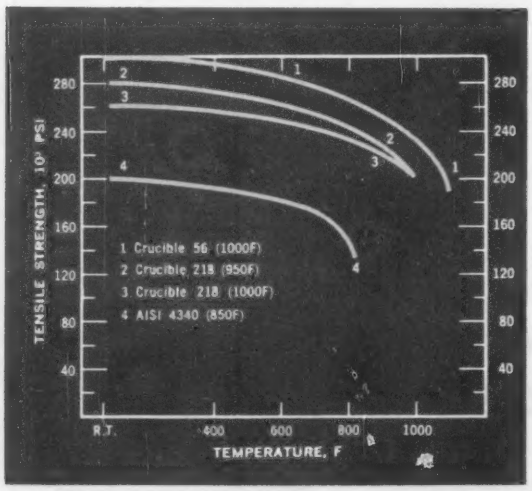


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

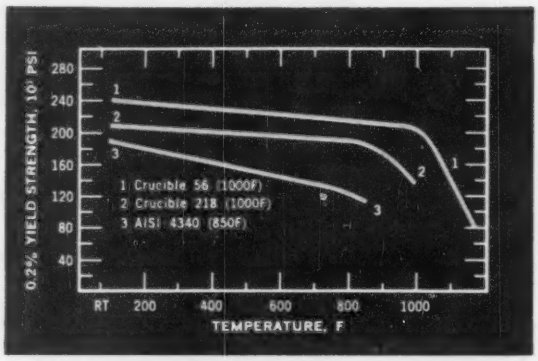


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

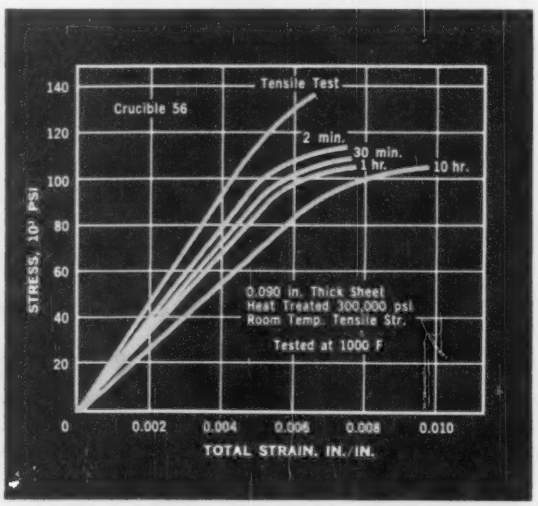


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

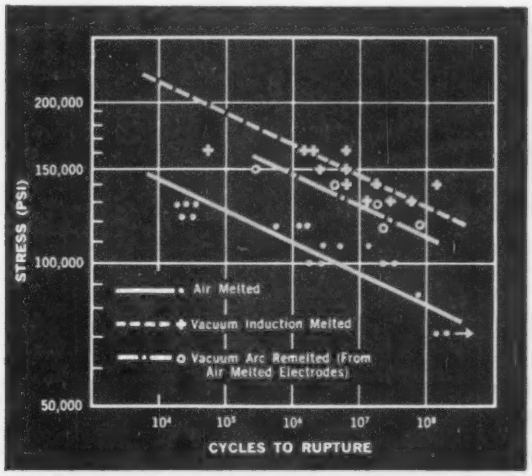
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	< 1
AM+VAR	7	70	< 1
VIM	5	3	< 1
VIM+VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EL07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

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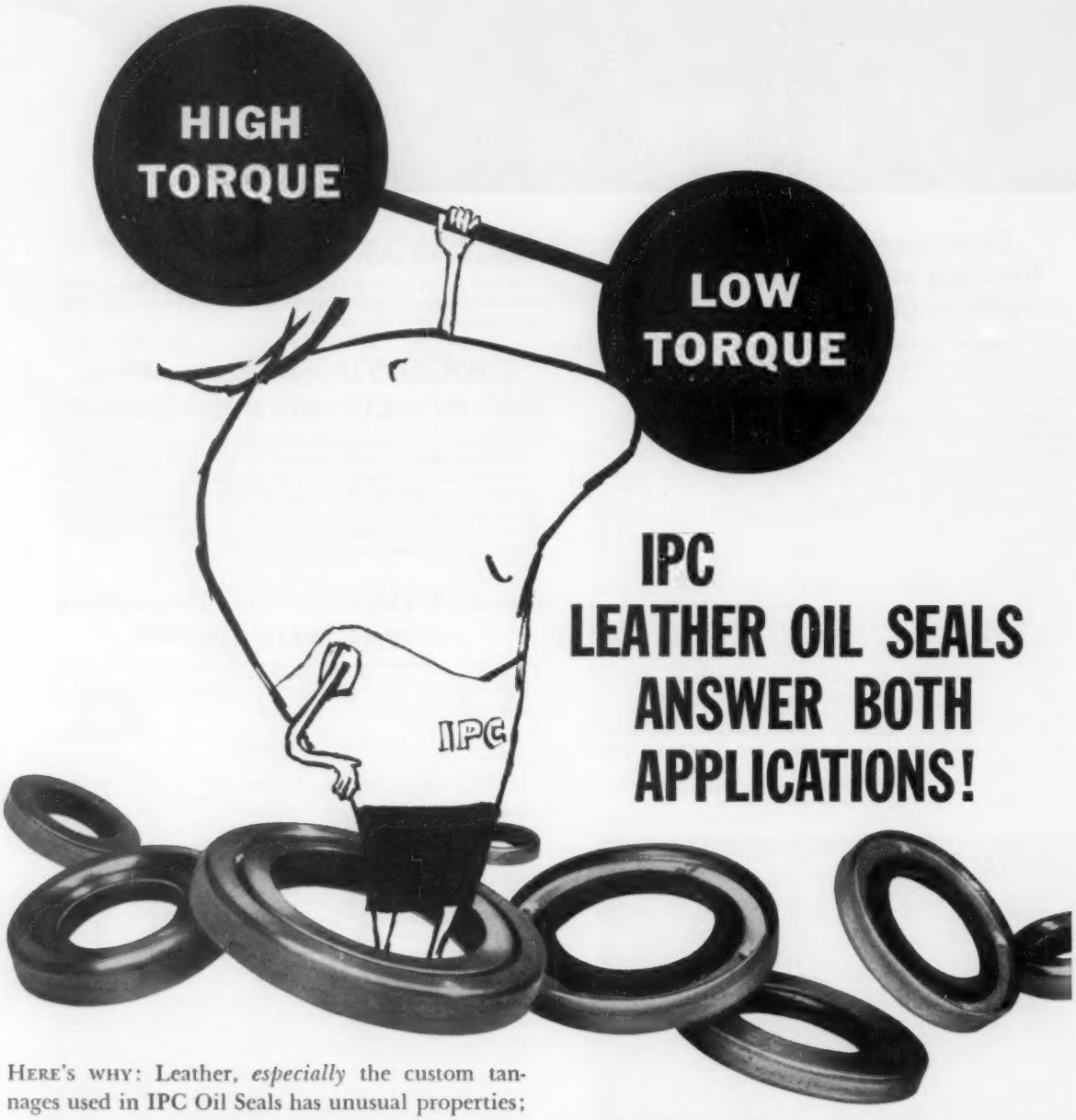

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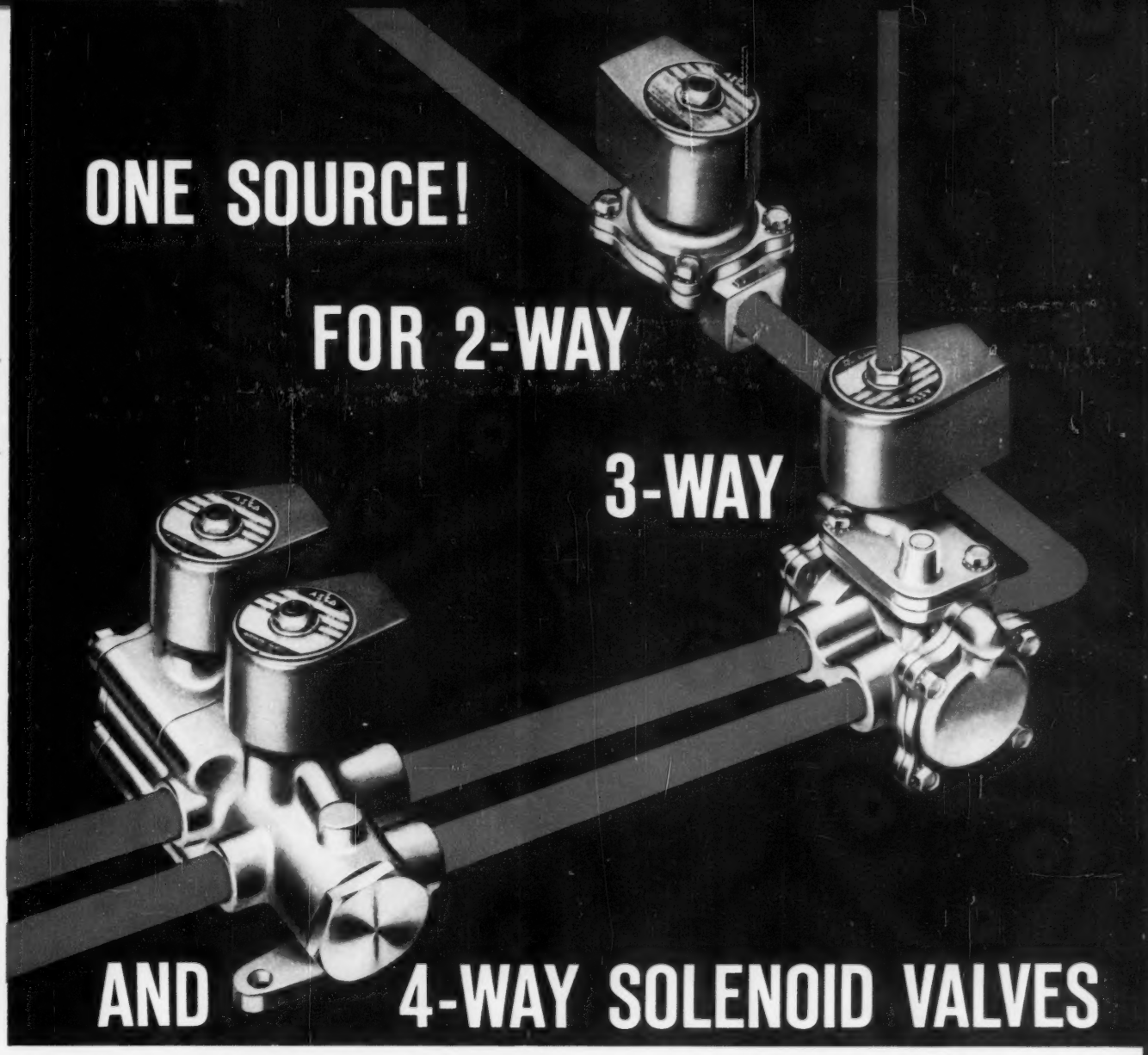

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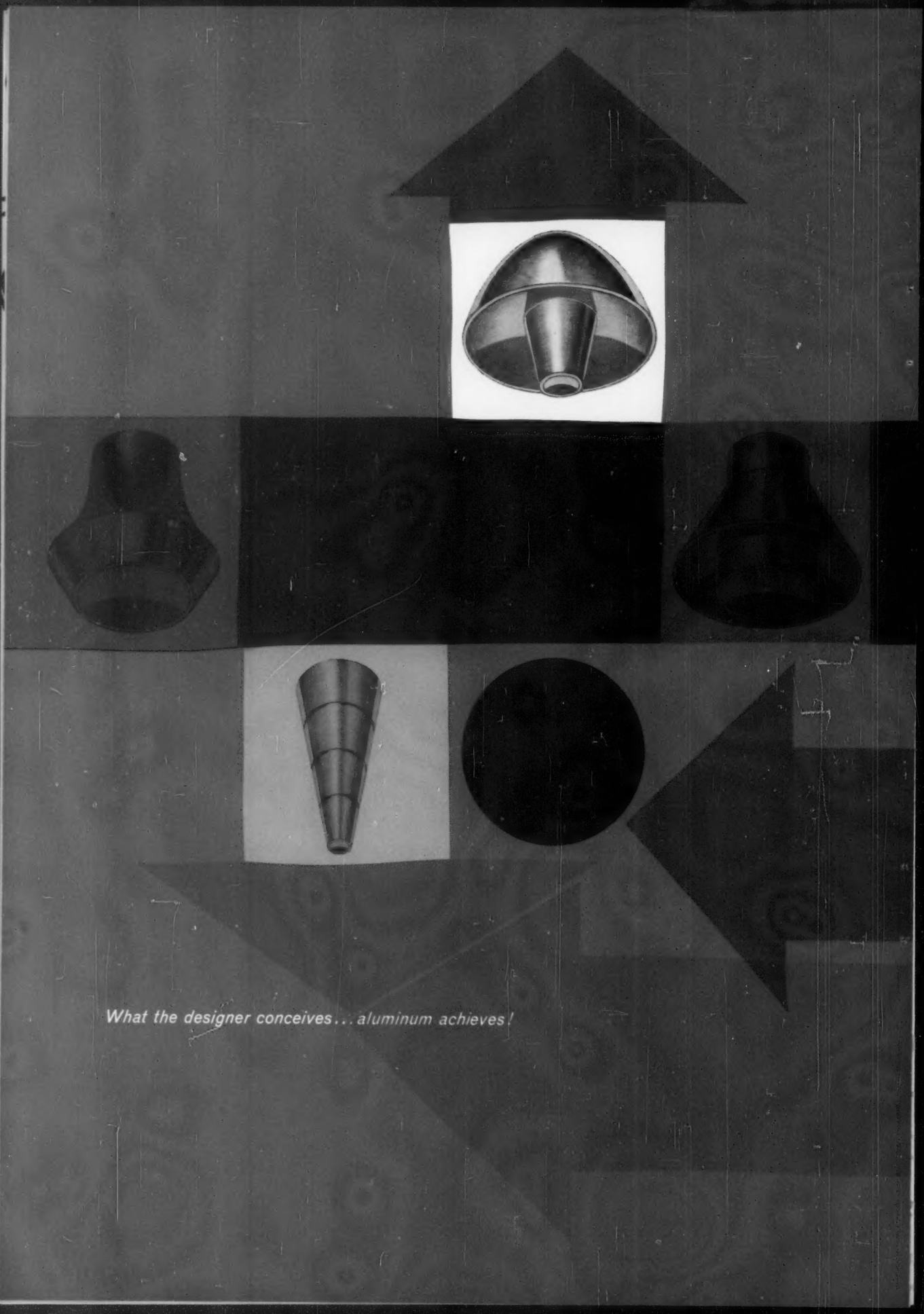

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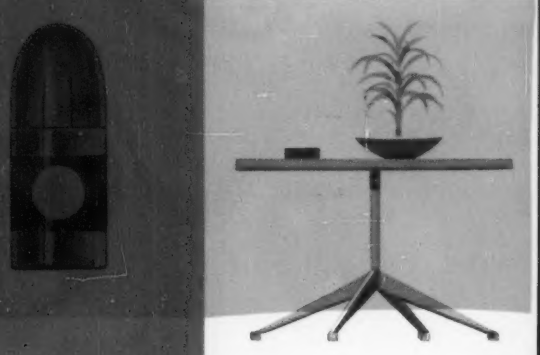

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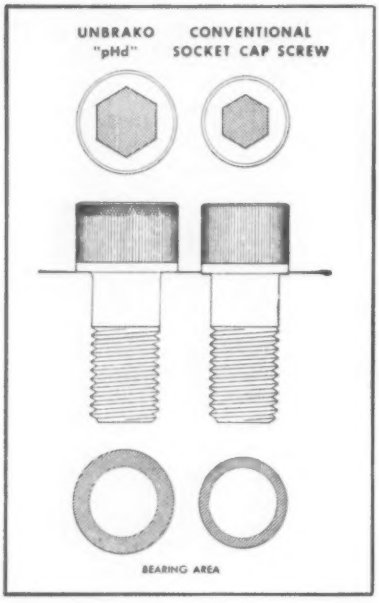

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Enlarged head diameter, without change in head height, increases usable fastener strength as much as 134%, provides as much as 233% more holding power. The greater clamping force achieved with the new UNBRAKO pHd means longer fastener life under dynamic loads, offers the following advantages:

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- Fewer loosened threaded fasteners under shock or vibration.
- Eliminates washers under the heads of cap screws where they are used to increase the effective bearing area.
- Minimizes effect of oversized holes on the head-bearing area.

The head diameter, enlarged on 5/16, 7/16, 9/16‡, 5/8, 3/4, 7/8 and 1 in. sizes, also prevents the screw head from indenting the material being assembled—a fault that normally reduces, and sometimes completely loses, the vital preload or tensile stretch that keeps the screw tight and prevents fatigue failure. pHd also provides room for a bigger socket, which permits tightening to higher recommended preloads.

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Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

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	Old	pHd	Old	pHd	Old	pHd		Old	pHd
1/4	.375	.375	.041	.041	3,280	3,280	–	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
3/8	.562	.562	.102	.102	8,150	8,150	–	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
1/2	.750	.750	.188	.188	15,000	15,000	–	1,450	1,590
9/16‡	.812	.843	.209	.247	16,700	19,700	18	2,050	2,270
5/8	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
3/4	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
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1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

†Normal recommended seating torques for unplated screws, fine threads ‡Available as a special only (listed for dimensional data)

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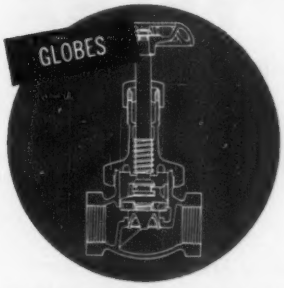

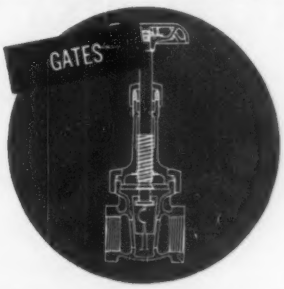

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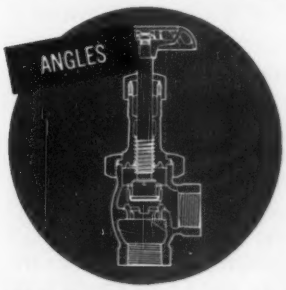

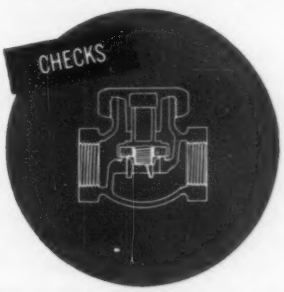

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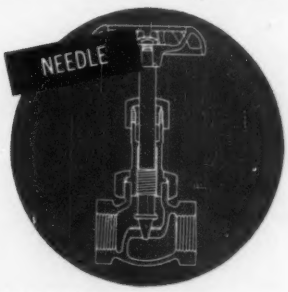

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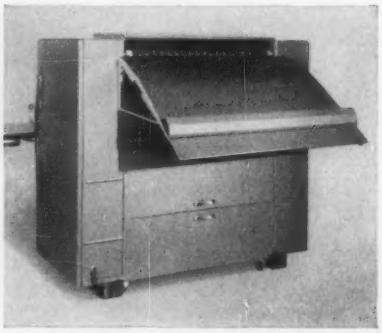

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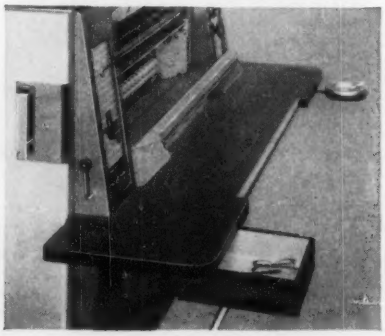

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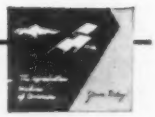

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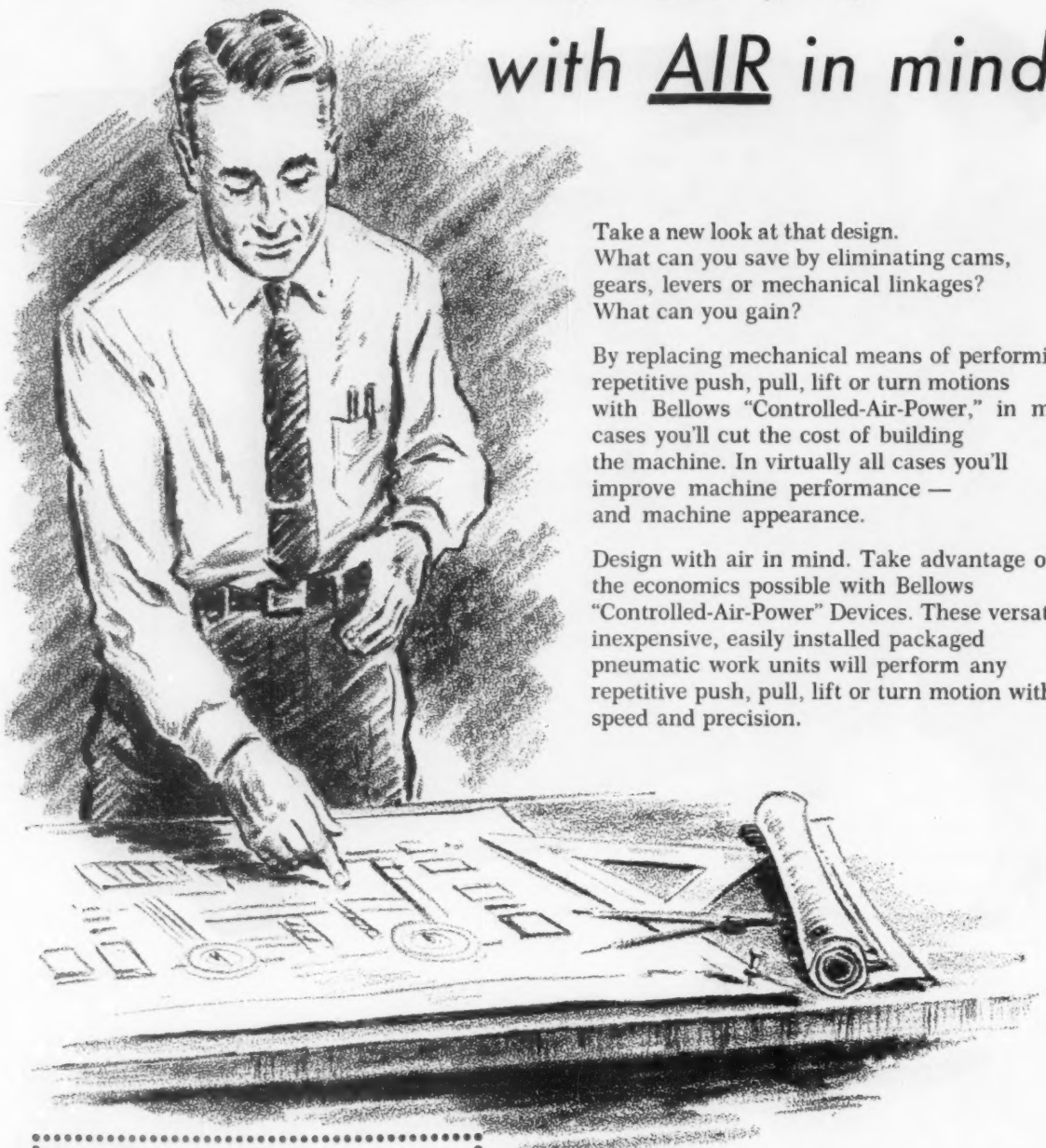

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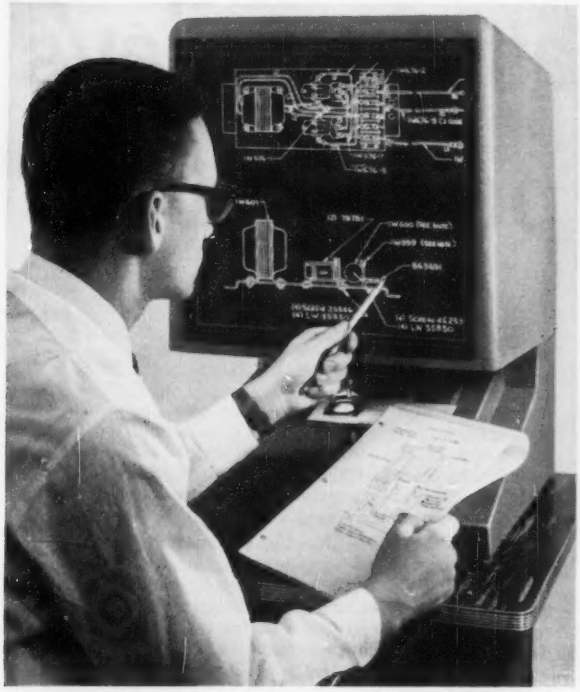

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Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever.

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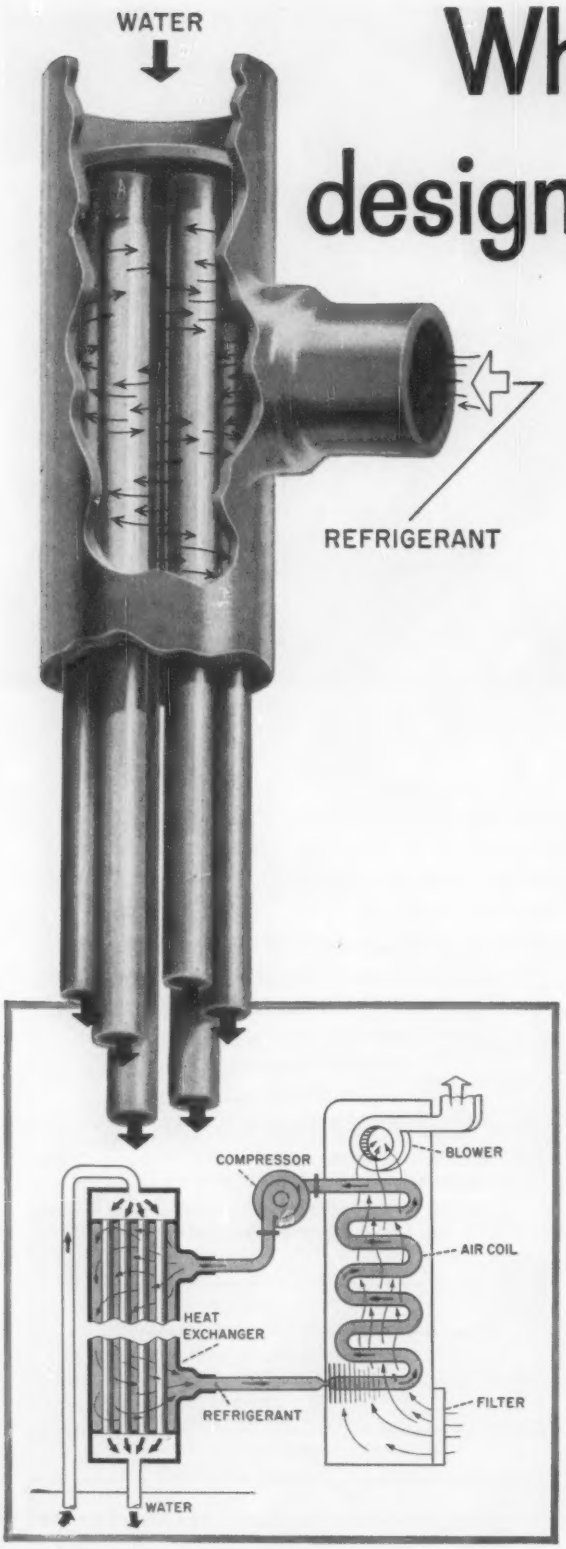
What are today's design possibilities?



Design possibilities with the copper metals are as varied as these metals themselves. The forty-two industry standard alloys and the hundreds of special copper alloys offer combinations of electrical, thermal, chemical, structural, joining and finishing properties which are more valuable in this day of rigid performance specifications than ever before.

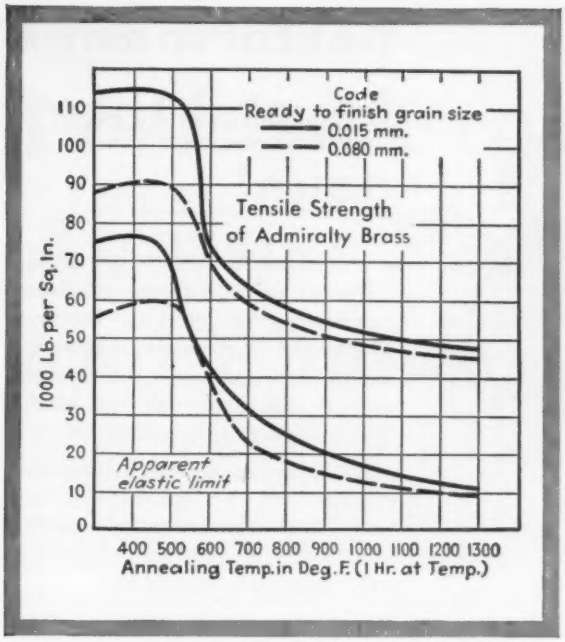
Today, most parts must meet several material requirements. Even a fastener, in addition to strength, may need corrosion resistant and high-finish properties. A supporting member may also have to conduct heat. Efficiency calls for materials versatility. And versatility calls for the copper metals. Although used since 7500 BC, copper is being re-examined as a new material with design possibilities that have scarcely been tapped. Here are some of the problems, and some of the properties that have special meaning at this time:

Design Problem — Heat pump condenser

The tube-in-tube condenser in a Typhoon Heat Pump must transfer heat between the ground water and the recirculating refrigerant. Corrosive sodium and sulphur compounds are dissolved in the ground water. The refrigerant, being highly volatile, must be confined in a leakproof system. The house air must be heated in winter and cooled in summer by passing over heat-transfer coils. The design requirements, then, include corrosion resistance, heat conductance and impermeability to the refrigerant. These requirements are met by three forms of copper. The ground water is contained in Admiralty Brass because of its excellent resistance to salt and sulphur corrosion. The refrigerant is contained in commercially-pure copper because of its density and the impermeability of its soldered joints. The air coil is a tinned copper fin soldered to a copper tube for maximum heat transfer at a realistic cost.

The good heat conductivity of copper and Admiralty Brass is, of course, important. But the conductivity of the metals themselves would be of little use if they did not also resist corrosion. The reason for this (besides durability) is because a heavy layer of corrosion products would severely reduce transfer efficiency.

TYPHOON HEAT PUMP CONDENSER SECTION (shown actual size). Heat exchange between ground water and refrigerant is accomplished in this unit. The corrosion resistance and high heat conductance of the copper metals used are vital to efficient operation. Drawing at bottom shows the complete cycles schematically.



← **EFFECT OF ANNEALING ON TENSILE STRENGTH** and apparent elastic limit of admiralty-metal strip, previously cold-rolled 6 B. & S Nos. (50% reduction of area) from two different grain sizes, 0.015 and 0.080 mm. (0.040-in. stock).

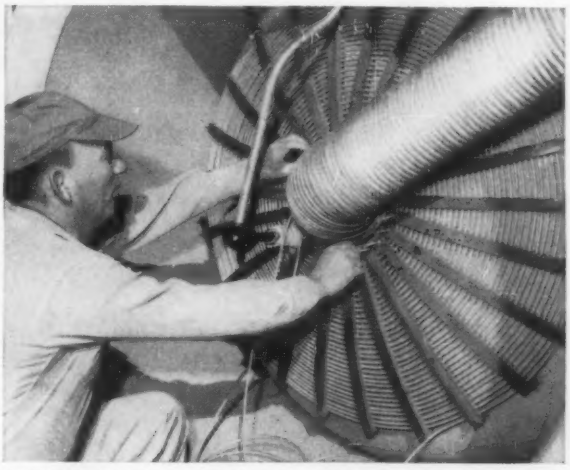
As with any piping system, impact and tensile strengths of the groundwater tubing are also important. Slight shifts in the substrata can produce heavy stresses. Admiralty Brass, as manufactured for this tubing, develops a tensile strength of the order of 45,000 psi. Many copper alloys are even stronger. The high-zinc brasses, nickel silvers, beryllium copper, the silicon bronzes and the phosphor bronzes can be processed to provide tensile strengths of the order of 140,000 psi for hard-drawn wire. Strengths, of course, vary with temper. The graph above illustrates the range of strengths for Admiralty Brass.

Design Problem — Preheating for atomic reactor

The induction heating coils used in the Organic Moderated Reactor Experiment, a nuclear power project operated by Atomics International, a division of North American Aviation, Inc., for the Atomic Energy Commission, keep the organic moderating compound in a fluid state during reactor startup and shutdown. The necessary high temperatures are generated by eddy currents in the reactor tank. The design requirements for the coils were high electrical conductivity and good high-temperature characteristics. Oxygen-free, high-conductivity copper was the answer. Its freedom from impurities assures high conductivity and guards against high temperature oxidation and scaling.

Design Problem—Yours

The combination of properties that you need for today's multifunction design requirements can probably be found among the copper metals. The copper industry will help you find it. The Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y., will welcome your inquiry.



COPPER COILS being installed on the bottom of the main core vessel of the Organic Moderated Reactor Experiment.

FINISHING REQUIREMENTS. The nickel silvers and low-zinc brasses are widely used in ornamental applications because of their ease of plating and finishing as well as their cold-working properties. The new fine-grain brasses offer an ideal surface structure for economical high finish.

The picture above shows various combinations of coppers and brasses used decoratively in housewares.

THERE'S A NEW FRONTIER IN...
COPPER · BRASS · BRONZE

. . . performance beyond the usual . . .

Design of high-speed precision machinery often calls for bearings which offer the utmost in load capacity, "hot hardness", dimensional stability. Each machine presents its own exacting requirements.

Fulfillment of unusual requirement combinations is a specialty at Rollway. Your selection of exactly the right precision radial cylindrical roller bearing is assured by:

- **A broad range of types and sizes, numbered in the thousands**
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ROLLER BEARINGS

Circle 429 on Page 19

Circle 430 on Page 19→

Positive Protection Against Phase Failure and Phase Reversal ?

Here is your answer!

The Allen-Bradley Bulletin 812 Type F, Type R, and Type RF relays provide positive protection against the hazards to men, motors, and driven machinery, resulting from phase failure and/or phase reversals.

The Bulletin 812 Style F phase failure relay employs a unique static sensing network that responds to all open phase conditions on a motor branch circuit and immediately removes the motor from the line . . . irrespective of the load on the motor (including no load), or the circuit arrangement. This relay even responds to hard-to-detect primary failures on a wye-delta transformer with ungrounded neutral. Furthermore, the five-cycle response prevents nuisance "drop-outs" from transient fluctuations.

The Bulletin 812 Style R phase reversal relay disconnects the motor from the line—whether it is running or not—when a phase reversal occurs anywhere in the system on the line side of the relay. Thus, it can be employed for a single motor, a group of motors, or an entire power system. In addition, the phase reversal relay prevents the motor from starting should phase failure occur while at a standstill—a vital feature for elevator applications.

The Bulletin 812 Style RF relay combines the elements of Style R and Style F relays for protection against both phase failure and phase reversal. All Bulletin 812 relays are inherently "fail safe." Send for complete information.

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd.
Galt, Ont.

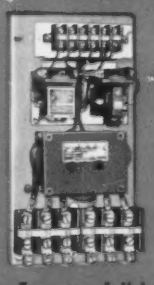
ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

12-58-MR

Bulletin 812, Style RF for Phase Failure and Phase Reversal

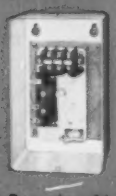
INDIVIDUAL RELAY UNITS AVAILABLE

For Phase Failure

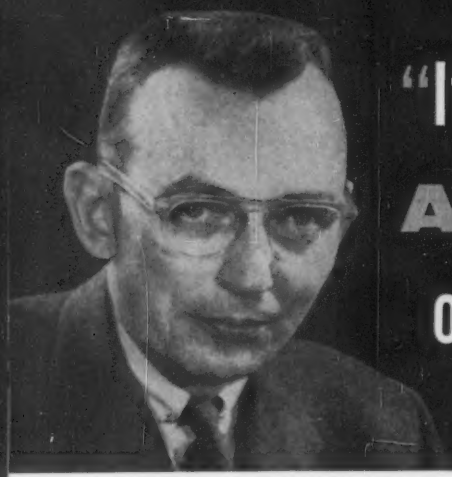


Style F covers full load currents from 1.5 to 300 amp in 4 sizes. Coils for up to 600 v, 60 cycles.

For Phase Reversal



Style R made with coils for 110, 208/220, 440, 550 v for either 50 or 60 cycle operation.

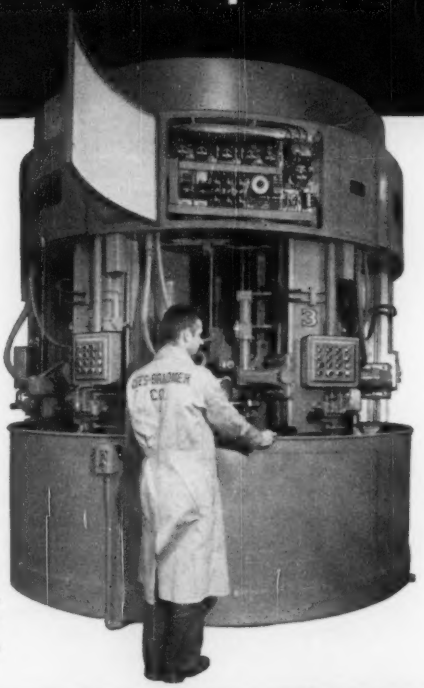


"If we stick to ALLEN-BRADLEY... our control troubles evaporate"

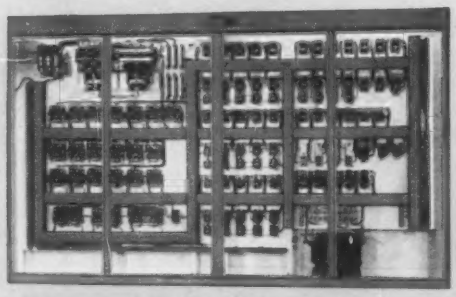
... so says John A. Bradner,
President, Lees-Bradner Co.,
Cleveland, Ohio, machine tool manufacturer.

"Yes, we have chosen Allen-Bradley controls. We use them, like them, and most thoroughly approve of them. We do our level best to see that they're the ones with which LEES-BRADNER machines are equipped.

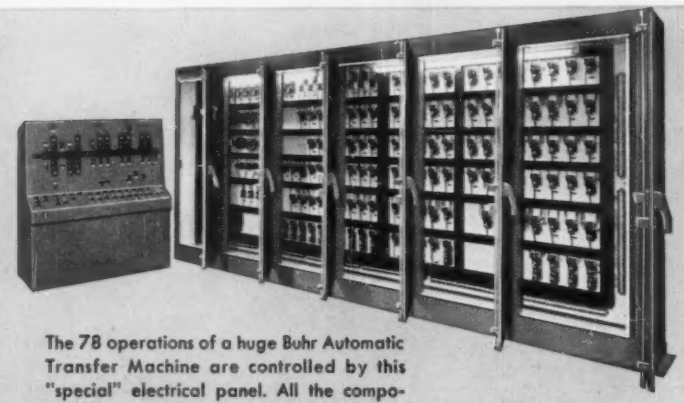
"It has been our experience in over 25 years of pioneering electrical rather than mechanical control of machine tools that, if we stick to Allen-Bradley, control troubles we are too apt to have otherwise—*evaporate!*"



Lees-Bradner Gear Hobbing Machine, above, uses six motor control panels assembled from standard A-B components.



This is the electrical control panel for a 12-station Kingsbury Indexing Automatic which performs 19 operations on an automatic transmission part. All the components in this panel are standard A-B control items.



The 78 operations of a huge Buhr Automatic Transfer Machine are controlled by this "special" electrical panel. All the components are standard Allen-Bradley units.

A-B QUALITY

ALLEN-BRADLEY

MOTOR CONTROL QUALITY

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12-38-I

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

One of the ways to judge a skilled craftsman is by the tools he uses. They're invariably the best he can find – chosen to lighten his work, sharpen his skills. And, if the craftsman is a draftsman, they are, more often than not, products of K&E.

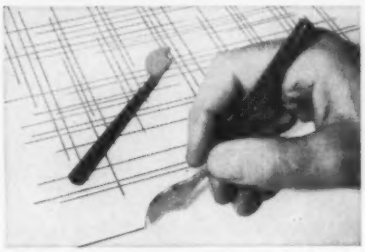
It may be that some of these products have escaped your attention (after all, we offer something over 8000 items). That's why we suggest you pay a visit to your K&E dealer whenever you can. It's a liberal education on what's new – as well as what's tried and true – in drafting equipment.

You'll find many products like these which can be highly useful in your work . . .

K&E "Quick Set" Bow Compass

The most remarkable feature of this compass is the speed and ease with which you can change settings–from diameters of 12 inches to 1/16 inch. With one hand, you can increase or decrease radii instantly and exactly. To go from small to larger radius, just press a spring release, and the legs will expand automatically. Stop approximately where you want, and make precise adjustments with a micrometer screw. To go from large to small, simply squeeze the legs of the compass together, then adjust precisely.

The K&E Quick Set combines the rigidity and precise adjustment of a standard bow compass, the simplicity and speed of a friction type compass, plus the finger tip control of K&E's unique design. You have to try the Quick Set to appreciate it fully. Two types are available. The N1071 fixed leg pencil compass, and the N1070 combination with interchangeable pen and pencil inserts. Both come with a box containing leads and spare needles. And with the N1070, a pen handle is provided for the pen insert which permits its use as a ruling pen. The compass can also be used as a divider by substituting one of the spare needle points for the lead in the pencil insert.

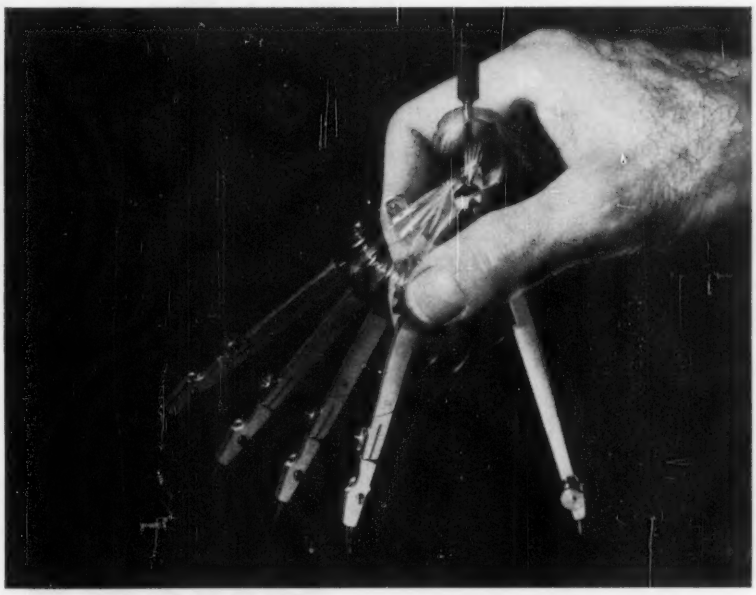


Marathon® Ruling Pens

K&E Marathon Long Line and Wide Line Ruling Pens (1092) hold an extra large ink supply – draw lines up to eight times longer than ordinary ruling pens. And because they are pre-set, line widths are always uniform, easy to match with complete accuracy. Ink flow is regular and even, lines are always sharp and clean edged.

An important feature of K&E Marathon Ruling Pens is that they will *not leak*. They can be laid on the work surface without risk of ink flowing out. That means you can fill several pens of different widths, use them as freely as you'd use pencils. They're easy to clean, too.

K&E Marathon Long Line Ruling Pens are available individually in line widths of .006, .009, .013, .020 inch – or in sets of three pens in line widths of .009, .013, .020 inch in a Leatherite case. Marathon *Wide Line* Ruling Pens come in line widths of .030 and .060 inch.



Leroy® Height and Slant Control Scriber

A versatile new Leroy scriber is now available which greatly expands the variety of lettering possible from a standard Leroy template.

Now, with the new Height and Slant Control Scriber (3237-12), you can form characters from vertical to slanting at any angle up to 45° forward. You can vary height from 60% to 150% of the size of letters on the template used. The width of letters remains the same.

Combinations of height and slant can be set quickly and easily. You just loosen the knob, move the scriber arm to the desired combination of height and slant, and tighten. That's all there is to it.

Stop in to see your nearest K&E dealer and ask to see these three products–small, perhaps, but mighty handy in the drafting room. Or drop us a line by mailing the coupon below . . .

KEUFFEL & ESSER CO., Dept. MD-12, Hoboken, N. J.

I'd like more information on:

- ☐ K&E Quick Set Compass
- ☐ Marathon Ruling Pens
- ☐ Leroy Height and Slant Control Scriber
- ☐ Please send me the name and address of my nearest K&E Dealer.

Name & Title_____

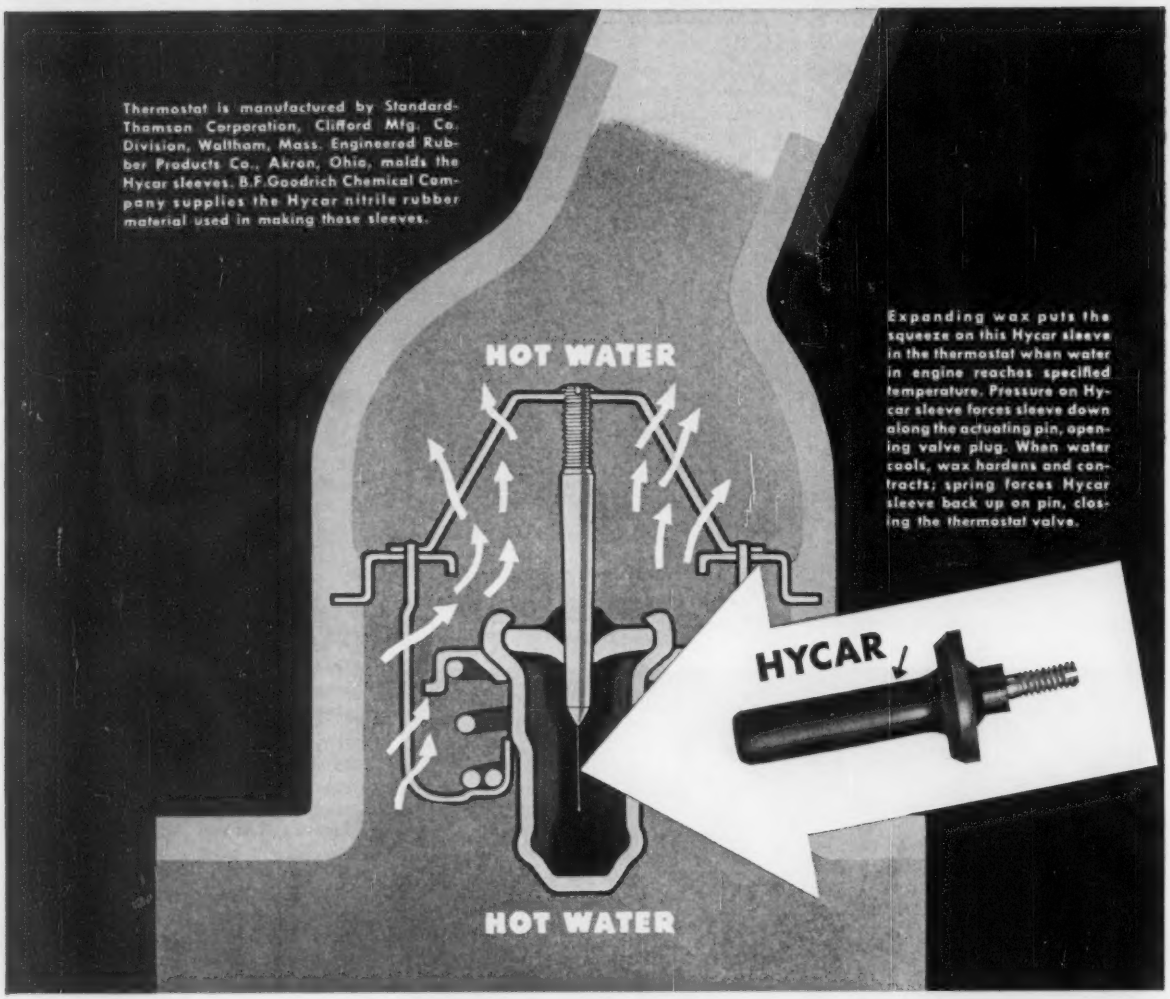
Company & Address_____

_____ 1613

Circle 432 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*


Thermostat is manufactured by Standard-Thomson Corporation, Clifford Mfg. Co. Division, Waltham, Mass. Engineered Rubber Products Co., Akron, Ohio, molds the Hycar sleeves. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber material used in making these sleeves.
HOT WATER
Expanding wax puts the squeeze on this Hycar sleeve in the thermostat when water in engine reaches specified temperature. Pressure on Hycar sleeve forces sleeve down along the actuating pin, opening valve plug. When water cools, wax hardens and contracts; spring forces Hycar sleeve back up on pin, closing the thermostat valve.
HYCAR
HOT WATER

Hycar controls heat of automobile engine operation

A SLEEVE of Hycar nitrile rubber solves a thermostat operating problem of high pressure cooling systems. Hycar is ideal because it is not affected by antifreeze chemicals or heat. It provides flexibility with high strength and exceptional resistance to volume change and abrasion.

Hycar nitrile rubber makes possible improved existing products and new products, too. Get information on it by writing Dept. KK-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
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GEON polyvinyl materials • HYCAR American rubber and latex
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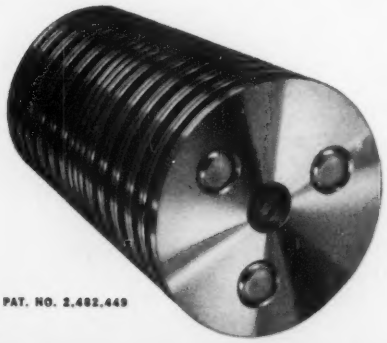
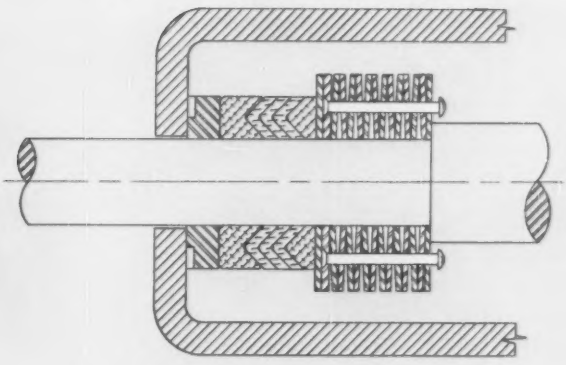
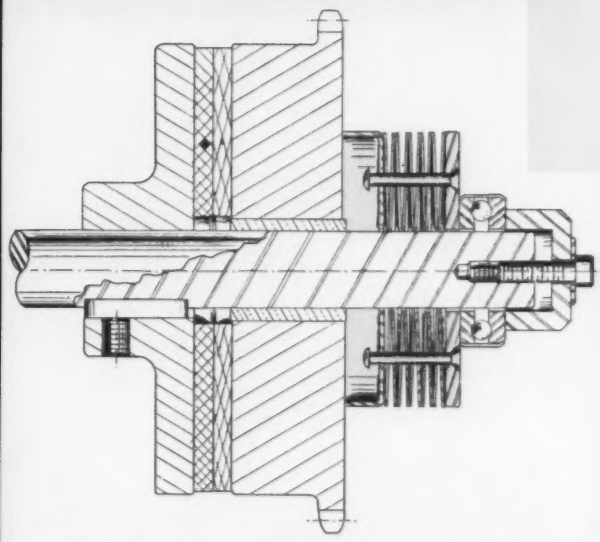


PAT. NO. 2,482,449



Typical installation of a "cartridge" of multiple Belleville washers in a shaft seal.



Typical installation of a "cartridge" of multiple Belleville washers in a clutch, such as in a machine tool drive.

Some uses of Belleville Washers as a spring ENERGY CARTRIDGE

Where loads are high, operating space limited, and conventional spring forms fail to qualify, Belleville washers in the form of an Energy Cartridge can be a welcome solution. Two such conditions are illustrated here.

By preassembling the washers in a single compact unit held together by pins or posts, installation is simplified and error is prevented in stacking loose washers in sequence. For varying loads, many combinations are available: in series, parallel or parallel series.

Belleville washers may be used for vibration isolation, as spring mountings for punch and impact presses, or to maintain constant pressure. For further information, write for pamphlets "Belleville Springs" and "Energy Cartridge." For engineering and production assistance on large or small requirements, contact the nearest A.S.C. Division listed below.

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
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Gibson Division, Chicago 14, Ill.
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Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Weldability—Welding is the only technique that we can use to join two pieces of metal so that they act as a single piece of metal.

Not *all* metals. Steel stands alone as the most weldable of all practical metals. Not *all* steels, but most of them can be welded without any sacrifice of strength or elastic behavior. More than that, steel can usually be welded without special precautions, without critical timing procedures, without excessive heat input, without elaborate and corrosive fluxes, without color change in the base metal, and with little danger of cracking. Welding engineers deserve most of the credit for the fact that steel can be welded so easily. With their help, steel producers have made many important break-throughs.

Before the 1930's, carbon and manganese were the main strength-producing elements in steel. Designers wanted stronger steels so they could build lighter structures—and they wanted to *weld* these steels because there is no lighter fastening system. But as the carbon content was raised to strengthen the steels, the weldability decreased and designers were handicapped because they had to fasten "lightweight" high carbon steels with heavy rivet and gusset-plate assemblies.

In 1933 United States Steel introduced the first *low carbon*, high-strength, low-alloy steel—USS COR-TEN Steel—and later USS TRI-TEN Steel. Both steels achieved 50,000 psi minimum yield strength with alloying elements other than carbon, and could be welded with normal procedures. The world of alloy steels was brightened, too, with the introduction a few years ago of USS "T-1" Steel, a constructional alloy steel combining tremendous strength (100,000 psi min. yield strength), toughness *and* weldability without requiring preheating or stress relief.

No matter what combination of properties you desire in a steel, there is a weldable steel that will do the job. In fact, there is theoretically *one* best steel for any application, and it can be selected from our family of Steels for Design: Carbon, High Strength, Alloy and Stainless. If you could use help in finding it, check United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

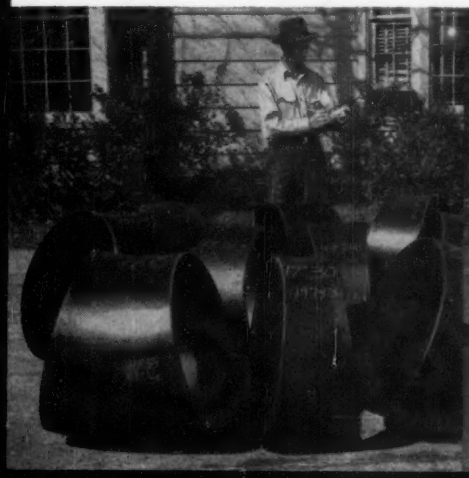
STEELS FOR DESIGN

Lower Left—Problem: Design butt-weld fittings for high-pressure oil and gas lines. Solution: Designer used USS TRI-TEN Steel, a high-strength, low-alloy steel particularly noted for its weldability. Pay-off: Fittings made lighter due to thinner plates; welding was fast and easy; less weld metal was needed; and the weld was as strong as the parent metal.

Lower Middle—Problem: Build a bedplate for a printing press requiring 534 welds. Solution: Builder used USS "T-1" Constructional Alloy Steel. Pay-off: Tremendous strength and toughness of "T-1" withstands thunderous impact from high-speed printing rollers and cutting knives—*and not one weld has failed.*

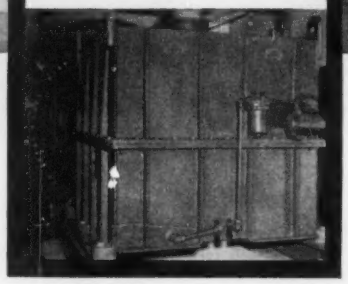
Lower Right—Problem: Convert a concrete reservoir into a storage area for 2,000,000 gallons of ammonium nitrate. Solution: Reservoir was lined with corrosion-resistant USS Stainless Steel sheets. Pay-off: Quick, easy installation because the Stainless sheets were welded right on the job—3½ *miles* of lap seams were welded and only two tiny imperfections were found when the welds were vacuum tested.

USS, "T-1," Cor-Ten and Tri-Ten are registered trademarks



(Above) Cutting 64 inch spiral bevel gear on new precision gear generator.

(Below) Interior of rotor test stand showing Philadelphia Spiral Bevel Reducer. 1300 hp motor is in background.



Special 1300 hp Philadelphia Reducer drives helicopter rotor test rig...

Testing 90-foot helicopter rotors involved problems of torque and vibration, plus precise speed control and test rig maintenance. Kaman Aircraft Corp., Bloomfield, Conn., found the answer in a special spiral bevel Philadelphia Reducer driven by a 1300 hp variable speed DC motor.

This Philadelphia designed drive completely eliminated vibration and torque variation previously encountered in engine driven rigs. Maintenance is simpler. Precise speed control can be obtained at rotor speeds from 200 to 400 rpm.

For any right angle drive application, standard or special, Philadelphia Spiral Bevel-Helical Reducers will take more abuse and last longer under the most severe load conditions. One of the reasons is that all Philadelphia spiral bevel gears and pinions are heat treated and hardened *after* they are cut . . . then lapped to a mirror-like finish. Helical Gearing is precision hobbed on the newest, most modern equipment. The gear teeth are then crown shaved and induction hardened.

Result: better tooth contact, longer gear life. Units are vibration-free and quieter. On special applications, where conditions warrant, both spiral bevel and helical gearing can be furnished with precision ground teeth.

You can select a Philadelphia Spiral Bevel Reducer—or have one specially built—to suit your precise needs. Our Spiral-Bevel units provide ratios as low as 1 to 1, or as high as 238 to 1. Units are available in single, double or triple gear reductions—in both vertical and horizontal types. Catalog SB-57 describes them all. Write for your free copy today.

PHILADELPHIA GEAR CORPORATION
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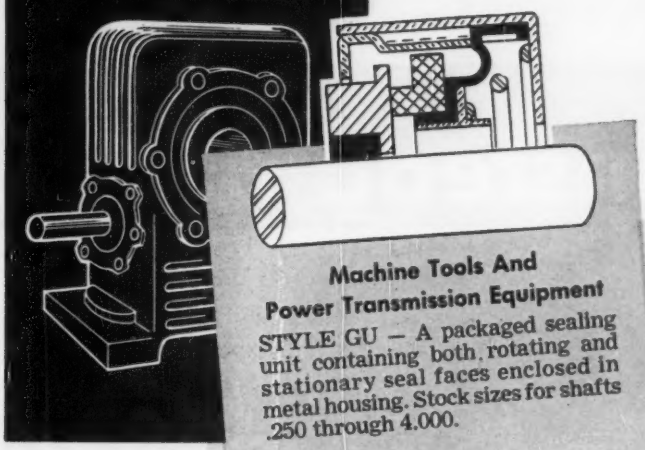
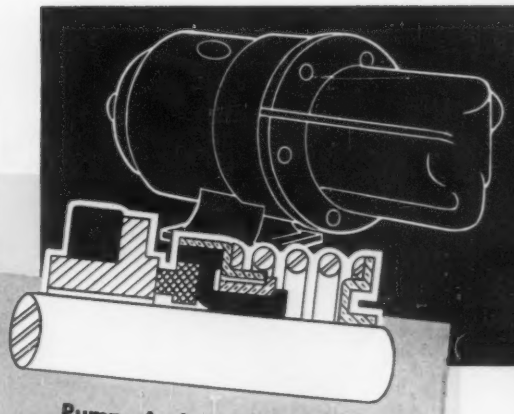
Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS



Machine Tools And Power Transmission Equipment

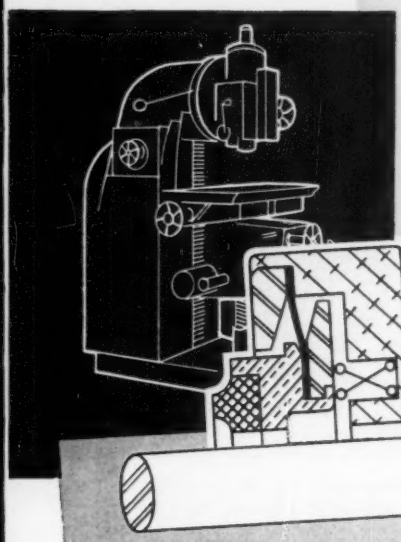
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

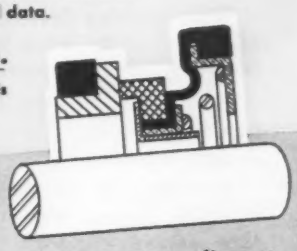
For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

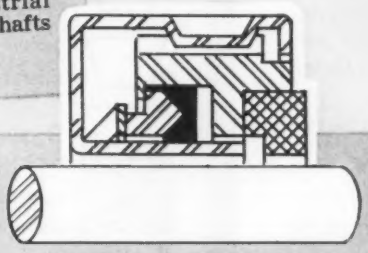
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



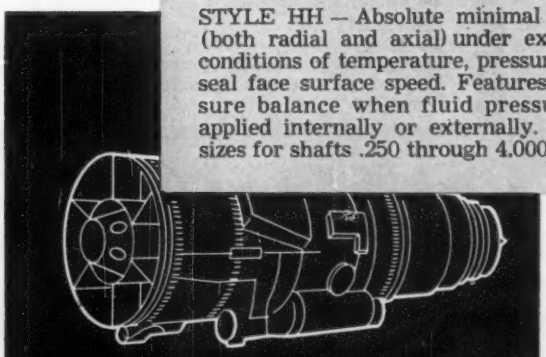
Household Appliances

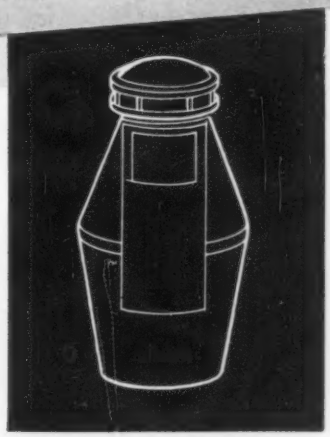
STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

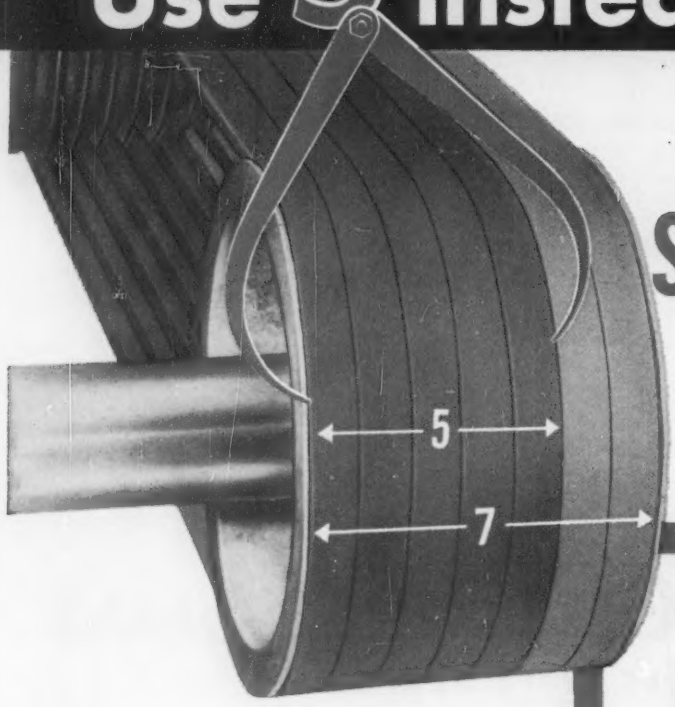
STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



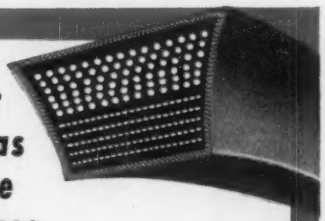


Circle 436 on Page 19

Use 5 instead of 7...



save { space / weight / cost



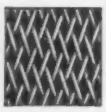
No other V-Belt has ALL these advantages

Money-saving fact: **A Gates Super Vulco Rope Drive delivers more HP per dollar invested than any standard V-belt drive.**

By using belts with 40% more horsepower capacity, you reduce sheave width and weight — save substantially in overall costs.

A wealth of drive data is always quickly available to you. Whether you need drive design service — or V-belts — or sheaves — just call your nearby Gates Distributor for a Gates V-Belt specialist.

Stocks carried in industrial centers throughout the world.



1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads ... reduce number of belts required ... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 3641

Gates Distributors are in the Yellow Pages

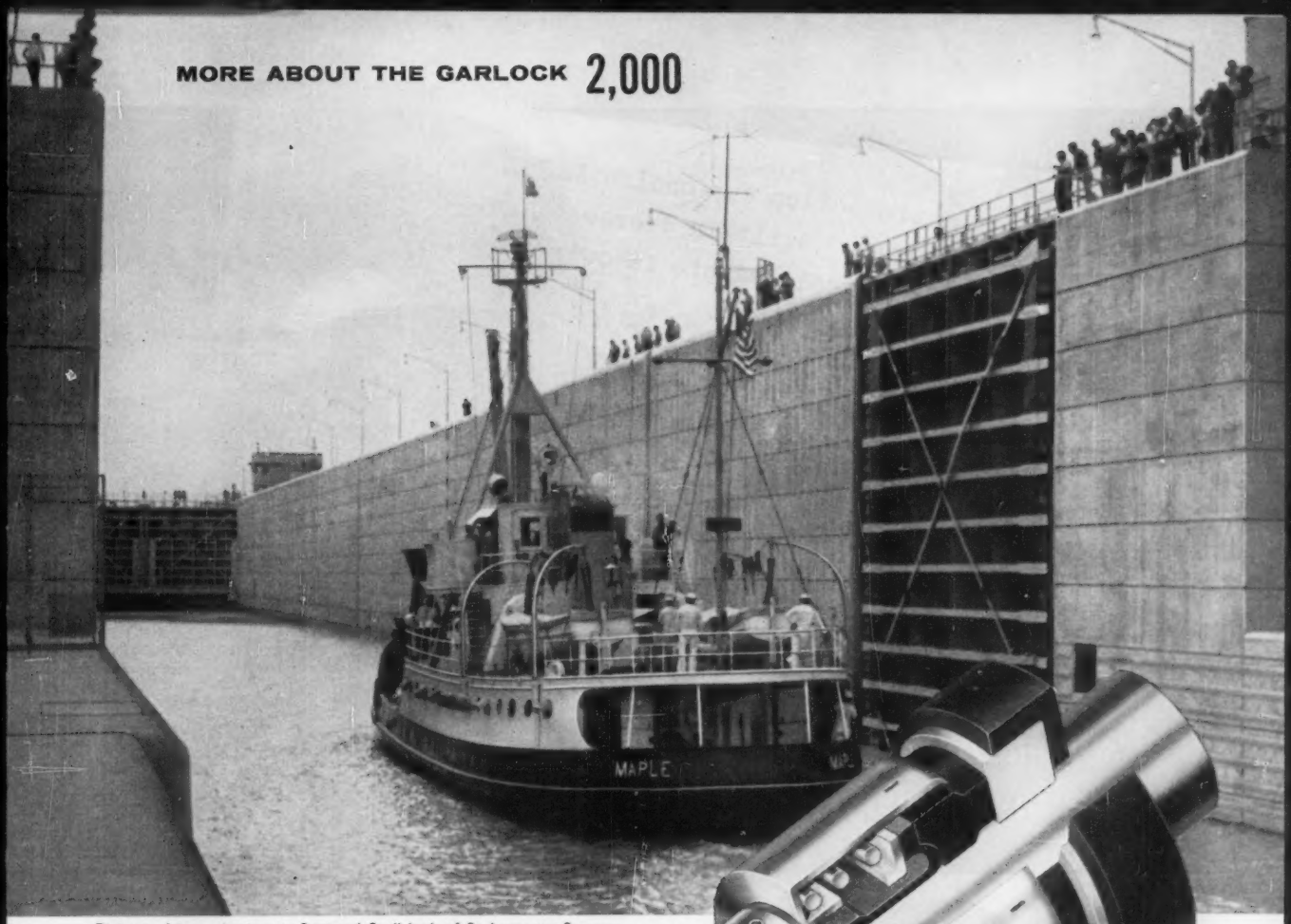
The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates — The Mark of *Specialized* Research

Gates Super Vulco Rope Drives

40% more Horsepower Capacity

MORE ABOUT THE GARLOCK **2,000**



First vessel to navigate new Bertrand Snell Lock of St. Lawrence Seaway completed on schedule with aid of Garlock Mechanical Seals.

GARLOCK SEALS help open SEAWAY on time

Builders save $100 Daily

PK MECHANIPAK —a completely self-contained seal with precision-lapped sealing faces as used on Seaway drainage pumps.

SUCCEEDING WHERE OTHERS FAILED, Garlock PK MECHANIPAK* Seals virtually eliminated seal failure on pumps used to minimize water seepage during digging of the Robinson Bay Locks. They withstood highly-abrasive clay, sand, gravel, and stone pumped out with water at a rate of 90,000 gph. Before PK MECHANIPAK Seals were applied, every four hours of pump operation meant one to two hours downtime for seal replacement. This not only consumed vital time, but forced a daily outlay of nearly $100 for new seals alone!

USE OF CERAMIC contributed to the seal's success at Robinson Bay. Ceramic is greatly superior in surface hardness and does not lose original shape under stress —thus, it was ideal against the rocky glacial till. As a stationary seat on the PK MECHANIPAK, it is precision-lapped for perfect contact with a carbon seal ring, thus eliminating leakage and increasing pump efficiency. On Garlock Mechanical Seals, no parts move on the shaft or sleeve; this removes the danger of shaft wear and scoring. The seals are completely self-contained, making installation simple. Once installed, no further adjustments are necessary.

KNOWN AS THE "SEAWAY SEAL" in the construction trade, PK MECHANIPAK Seals are another of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Folder AD-150.

*Registered Trade Mark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 438 on Page 19

For thermal protection our choice is KLIXON Motor Protectors. Built-in overheat protection has been an integral feature in over 1,000,000 WASTE KING disposers.

Waste King Corporation

Proof again that

KLIXON PROTECTORS

safeguard motors against burnouts

"Imperial Hush" food waste disposer, manufactured by Waste King Corporation, largest builder of domestic and commercial garbage disposers, takes the mess out of the kitchen and washes it down the drain.

To assure dependable operation of its units and to safeguard the motors from burnout, Waste King uses motors equipped with KLIXON Inherent Overheat Protectors in its disposers as well as in its dishwashers.

The reason . . . their experience proves that KLIXON Protectors can be depended upon to produce maximum motor performance with minimum failures under abnormal operating conditions.

Should the motor become dangerously overheated due to overloads, stalled rotor or other causes, the KLIXON Protector snaps the power off. The power remains off until the motor has cooled to a safe temperature and the reset button is manually pushed.

You, too, can obtain maximum overload capacity in the motors that operate your equipment by specifying and using KLIXON Protectors. Their use will reduce maintenance costs, service calls, and repairs and replacements. The additional cost is low, pays for itself over and over by eliminating motor burnouts. For details write for Bulletin MOPR-1.

METALS & CONTROLS CORPORATION

Spencer Division 3212 Forest Street, Attleboro, Mass.

KLIXON®

Circle 439 on Page 19

DOES YOUR DESIGN CALL FOR SCREW MACHINE PARTS?

Cut costs with ALCOA® Aluminum. It gives three times more parts per pound because it weighs only a third as much as steel or brass. Add aluminum's high scrap value . . . and you can save up to 30 per cent in material costs alone.

Light weight also adds design freedom. ALCOA Aluminum Screw Machine Stock helps you cure inertia problems without sacrificing strength or performance. Moving parts wear less because there's less resistance to applied force. Designers of automotive parts, business machines, ordnance, have proved it.

Aluminum offers exceptional machinability, limited almost entirely by machine capacity . . . high electrical and thermal conductivity . . . and choice of any finish, including lustrous, lasting anodized color.

Aluminum is versatile. Each of ALCOA's four screw machine stock alloys has significant advantages. Specify 2011-T3 for machinability; 6061-T6 for exceptional corrosion resistance and finishing characteristics; 2024-T4 for strength; and 2017-T4 for economy.

Argus, Johnson Motors, Leviton and other companies that switched to ALCOA Aluminum tell why in a booklet we've prepared. We'd like to send you a copy. Just mail the coupon.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

ALCOA THEATRE
Fine Entertainment
Alternate Monday Evenings

Look for this label . . . it's your guide to the best in aluminum value

Aluminum Company of America
873-Z Alcoa Building, Pittsburgh 19, Pa.

Please send your new booklet about the switch to Alcoa Aluminum Screw Machine Stock.

Name_____
Position_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 440 on Page 19

It's a Life Saver

because this sensitive

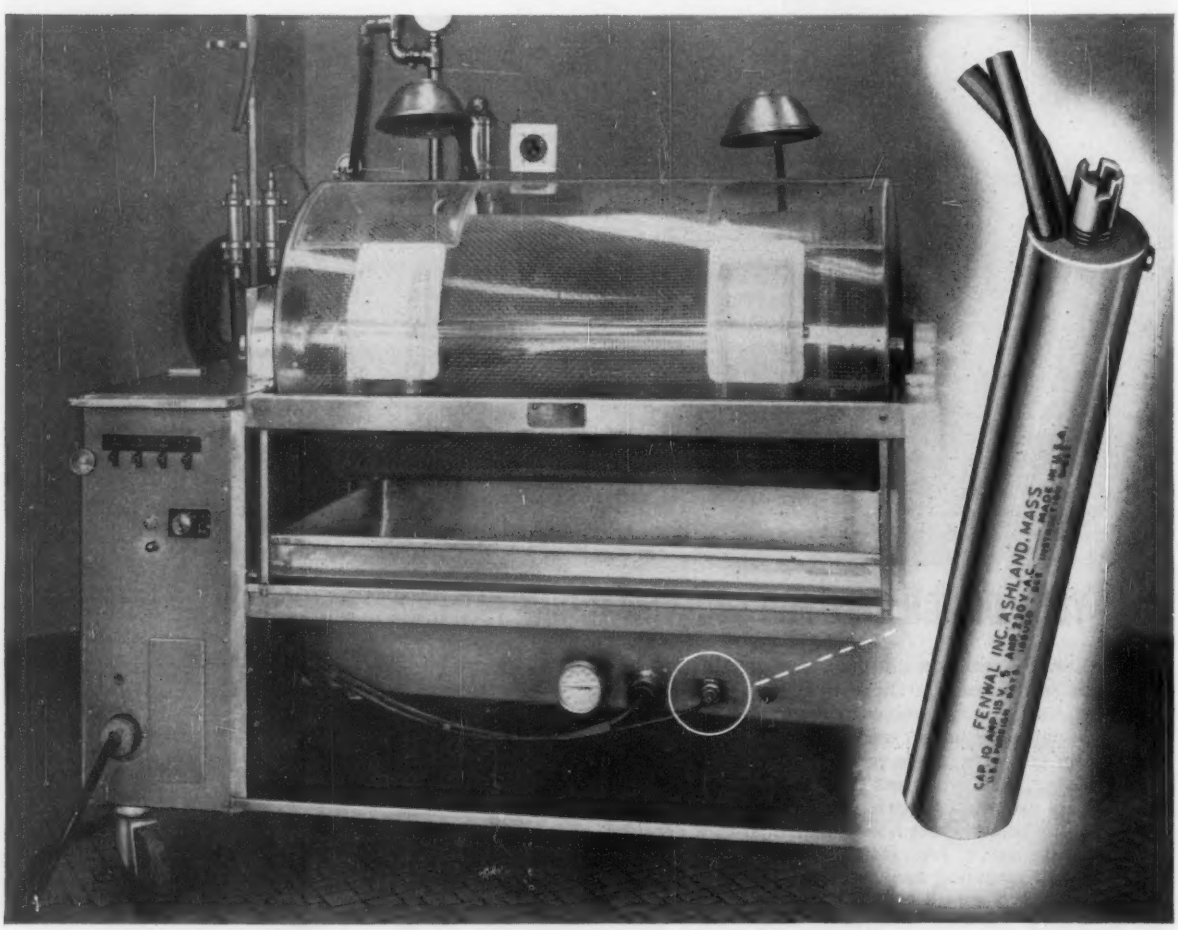
Fenwal THERMOSWITCH® unit controls temperature precisely

Where precise control is necessary, customers have been relying on Fenwal THERMOSWITCH Temperature Controls for years. That's because Fenwal THERMOSWITCH units are extremely sensitive and they last. Consistently they provide one half million cycles or more of precision temperature control. *You get reliability!*

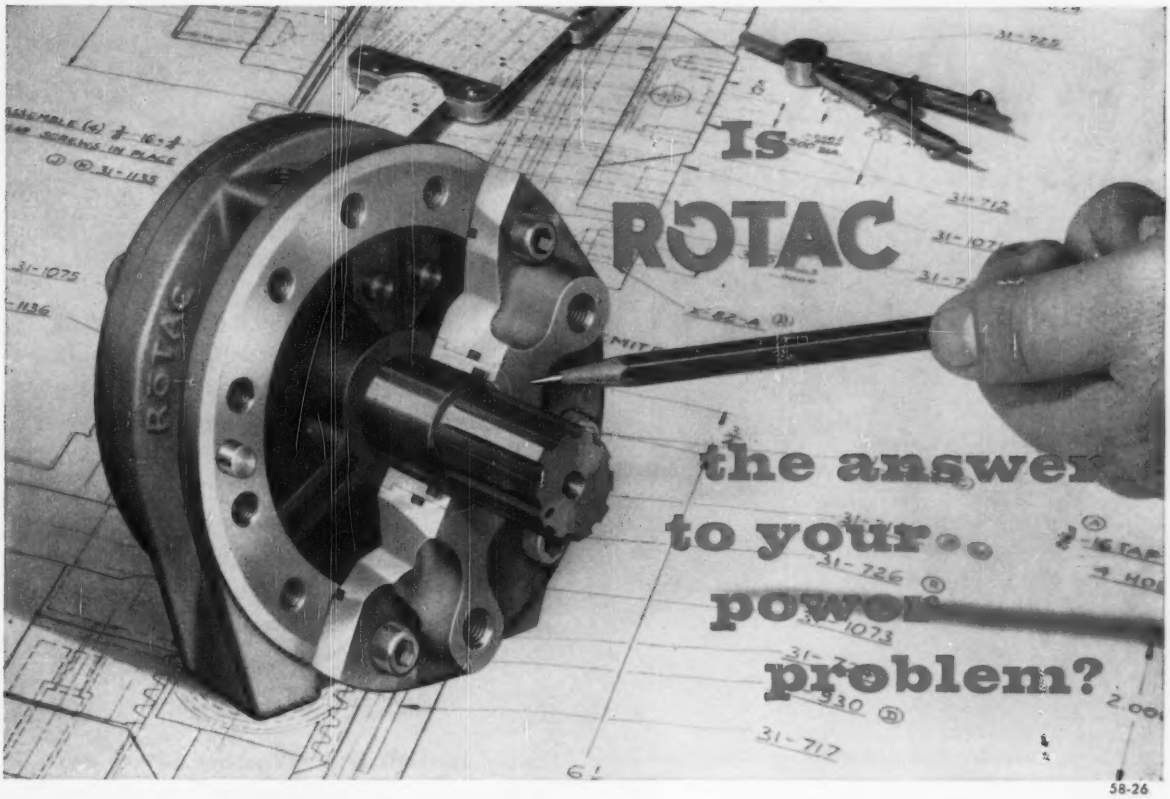
The entire shell is the sensing element of THERMOSWITCH units, giving more heat responsive area and faster reaction to temperature change. This, plus a design based on differential expansion of metals, gives control in fractions of degrees. *You get precision control!*

Fenwal THERMOSWITCH units can help your equipment run faster, require less maintenance, and be more flexible. For information on the model best for your application, write to Fenwal Incorporated, 1912 Pleasant Street, Ashland, Massachusetts, and we'll send you our catalog MC-135 or a sales engineer, whichever you want.

This is our series 17000 in an artificial kidney. This medical equipment has been instrumental in saving the lives of many people suffering from uremic poisoning. Each time the patient's blood passes through the artificial kidney, more poison is filtered out. The Fenwal THERMOSWITCH unit controls the rinsing bath so that blood returns to the patient at body temperature.



Fenwal CONTROLS TEMPERATURE . . . PRECISELY



Rōtac torque actuators are simple, compact—provide positively controlled power for any movement from turning watch parts to tipping railroad cars

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained.

There is no complex linkage, no plunger action: RŌTAC's few moving parts are completely sealed from dirt and natural elements. Patented O-rings are used around vane, shoe and end caps.

RŌTAC Torque Actuators can be mounted easily—vertically, horizontally or at any angle—with the housing held stationary, or with the body rotating around the shaft.

To simplify design problems, for versatility in extended applications, specify RŌTAC Actuators for powerful, easily controlled rotary motion in compact form.

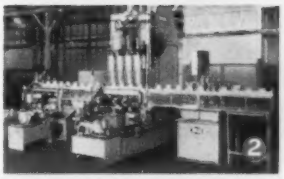
FREE DESIGN DATA BOOK—20 PAGES

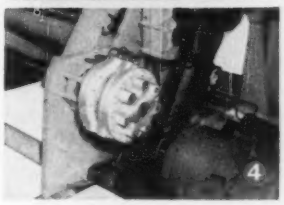
Contains everything you'll want to know about RŌTAC — Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

EX-CELL-O CORPORATION

GREENVILLE PLANT, GREENVILLE, OHIO

EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • TORQUE ACTUATORS • DAIRY EQUIPMENT





Just 4 of the hundreds of recent applications

1. MOBILE EQUIPMENT—A compact RŌTAC Actuator swings truck crane boom in 280° travel arc; it's controlled by a 4-way valve.

2. MACHINE TOOLS—Automation machine for boring, grooving piston wrist pin holes uses RŌTAC Actuator to orient arbors for hole alignment.

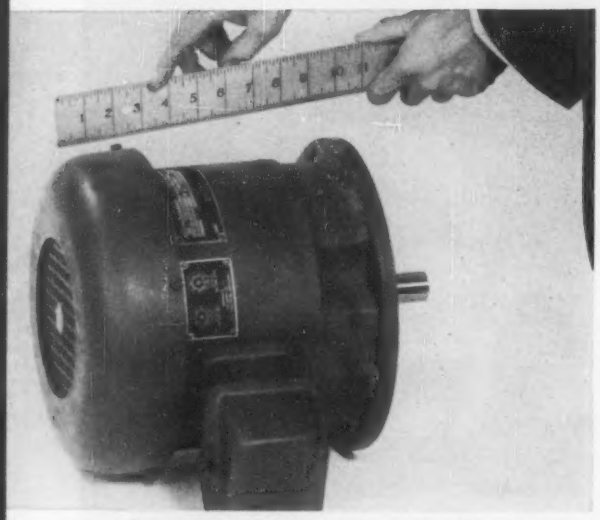
3. FOUNDRY MACHINERY—RŌTAC Actuators supply motive power for turnover of the core-box on semi-automatic shell core blower.

4. PAPER MACHINERY—Collector roll is actuated by a Model HN-63-1V RŌTAC Actuator which unloads material after slitting operation.

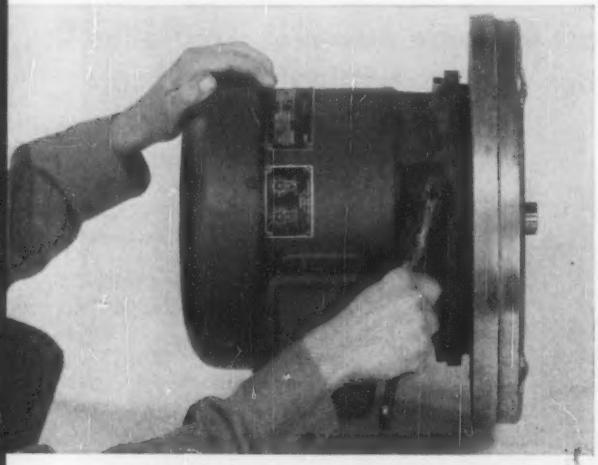
XLO EX-CELL-O FOR PRECISION

From Century Electric

A NEW MOTOR
up to five inches shorter

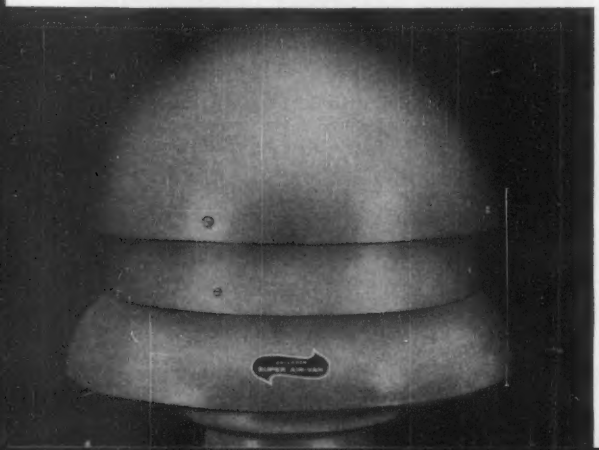


Century Electric 5 hp short motor is 4⅞ inches shorter than standard 5 hp motor.



(above) Standard flange gives flexibility in mounting. Motor can be installed horizontally or vertically.

(below) This compact power roof exhauster is typical of applications for short motors.



You have greater product design freedom with the new Century Electric short motor. It is two and a half to five inches shorter, but has all standard integral motor features. Here are the benefits:

Save space and weight – Your product can be smaller, lighter, a different shape . . . because the new motor is up to 35% shorter and has less bulk and overhang. Means you also reduce handling costs—both in receiving motors and shipping your product.

Easy mounting – You can use this motor in place of any standard end-mounted motor because it has a standard flange. It can also be mounted horizontally, vertically, or at any angle. Its small size makes it possible to mount the motor in a variety of places on equipment.

Variety of applications – You can get the new Century Electric short motor in totally enclosed or open frames and in ratings up to 15 hp. You can use it on many applications such as machine tools, roof ventilators, pumps and centrifuges. And it has the same quality features and high standards of all of Century Electric's complete line—up to 400 hp.

More than a motor – This motor is the result of a continuing search for ways to meet industry's needs. Another reason why you get more than a motor from Century Electric.

For more information, contact your nearest Century Electric Sales Office or Authorized Distributor.

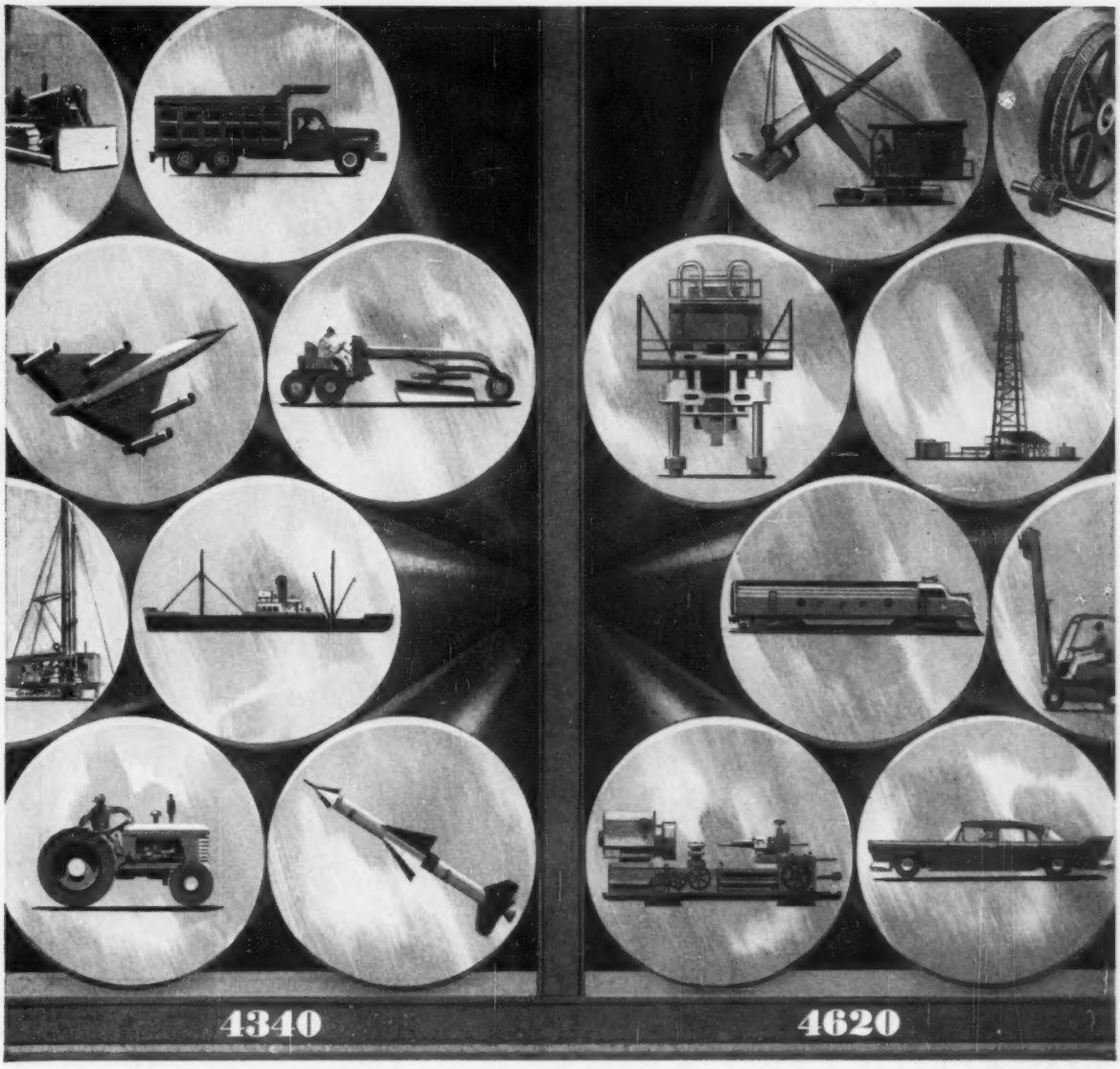
CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

58-8

Circle 443 on Page 19



No matter what you make...

look to these two general purpose steels to standardize, simplify, and save money!

4340 THROUGH-HARDENING

4340 stands alone among medium carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy cross section.

4620 CARBURIZING

4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.

AMERICAN STEEL WAREHOUSE ASS'N.

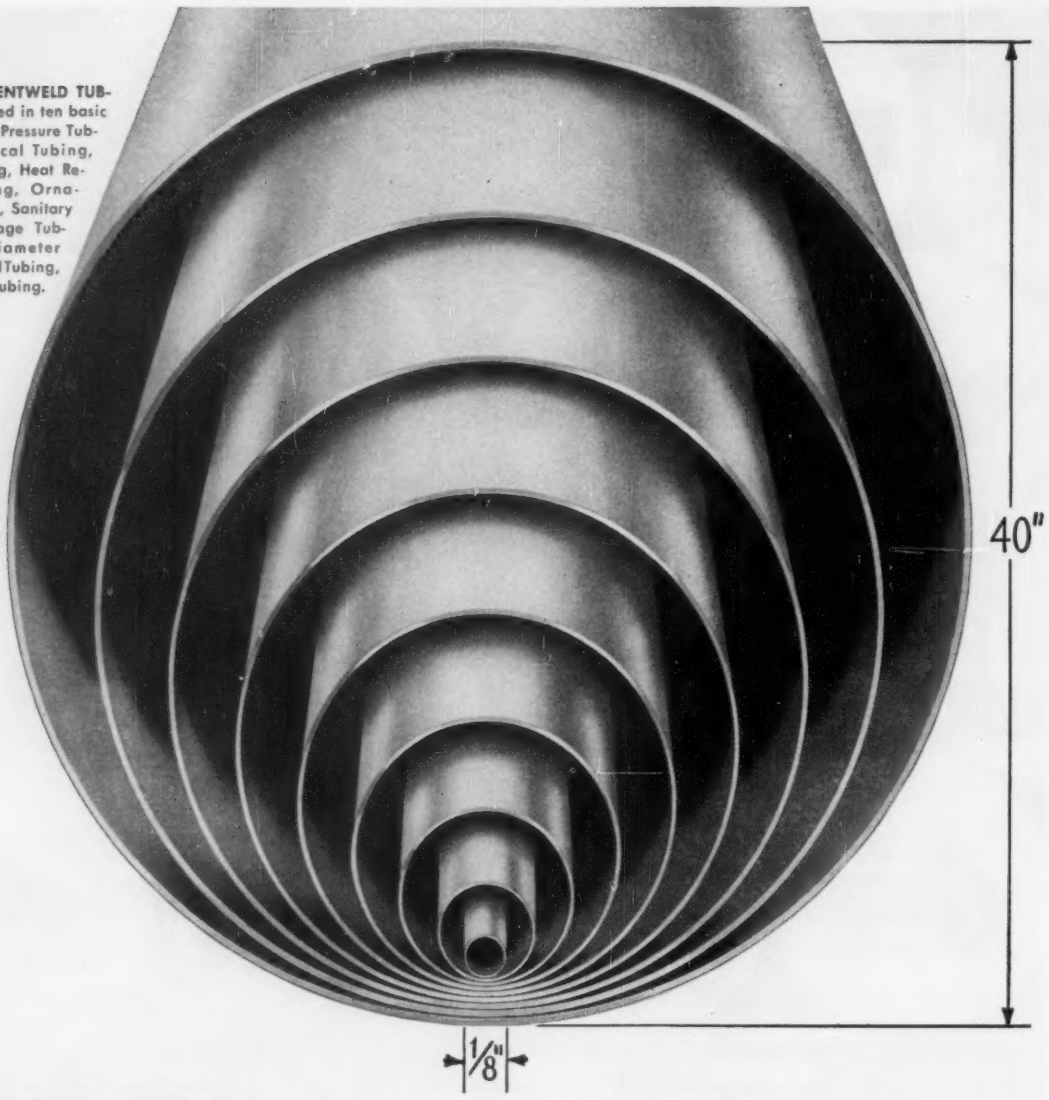
Easy to Get *... Both these steels are carried by many Steel Service Centers from coast to coast* ... ready for delivery on a "next door" basis. For a list of names and addresses of Steel Service Centers that carry AISI 4340 and 4620, write us.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street New York 5, N.Y.

INCO TRADE MARK

CONTOUR TRENTWELD TUBING is furnished in ten basic classifications: Pressure Tubing, Mechanical Tubing, Aircraft Tubing, Heat Resistant Tubing, Ornamental Tubing, Sanitary Tubing, Beverage Tubing, Large Diameter Tubing, Shaped Tubing, and Formed Tubing.



TRENTWELD tubing is equal in strength and has more uniformity than tubing made by any other method of manufacture

Trent offers tubing in sizes ranging from ⅛" to 40" O.D. and in a wide range of grades. These include: Hastelloy,* Zirconium, Zircaloy, Titanium and 19-9-DL grades. All are made by an exclusive welding process—Contour Trentweld®—which virtually eliminates the bead. Furthermore, by cold working and annealing after welding, Trent makes the weld equal in strength and corrosion resistance to the parent metal.

To insure that Trentweld tubing is of the highest quality attainable, a rigorous quality control program is carried out. Samples of each lot are tensile tested. Periodic tests — flattening, reverse bend, flare and flange, coil, and pressure — are conducted. Rigid corrosion tests are made on all lots intended for corrosive applications. When requested, a unique "single-wall" X-ray inspection is made as your final assurance of a sound, uniform product.

Why not take advantage of Trent *quality* when you order stainless or high alloy tubing? For further information, write for the Trent tubing handbook, Trent Tube Company, East Troy, Wisconsin.

*Trademark of Haynes, Stellite Co.

CONTOUR TRENTWELD

TRENT TUBE COMPANY

Subsidiary of Crucible Steel Company of America

GENERAL OFFICES: EAST TROY, WISCONSIN
MILLS: EAST TROY, WIS.; FULLERTON, CALIF.

Circle 444 on Page 19

Circle 445 on Page 19→

Now...MORE ball bearing types and a bright, new package

Hoover is widely known as a leading producer of open, shielded and sealed types of deep-groove ball bearings, double row bearings and water pump bearings. These Hoover products have earned a long standing reputation for quality.

Now, three new series are added to the Hoover line: **1**) pillow block bearings and companion flange bearings; **2**) 3L00 extra light bearings for maximum shaft and minimum housing dimensions; **3**) "Super Max" bearings for maximum capacity applications.

All these new bearings meet Hoover's high quality standards. All are made with smooth *Hoover Honed* raceways and *Micro-Velvet* balls, accurate within millionths of an inch. All are designed for superior performance and long life.

New, too, is the distinctive blue and yellow package, designed to help you recognize Hoover bearings quickly and to remind you that they are *tops in quality*.

hoover

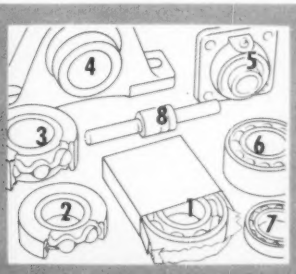
BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Los Angeles Sales Office and Warehouse: 2020 South Figueroa, Los Angeles 7, California

Chart at Right Identifies Bearings Pictured Above
Use Squares to Check the Information You Want.

- ☐ **1** Single Row Deep Groove Bearing.
- ☐ **2** Lubricated-for-life Bearing with Seals of TEFLON*.
- ☐ **3** Cartridge Bearing.
- ☐ **4** Pillow Block Bearing.
- ☐ **5** Flange Bearing.
- ☐ **6** Double Row Bearing.
- ☐ **7** 3L00 Extra Light Bearing.
- ☐ **8** Fan and Water Pump Bearing.



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Title _____

Company _____

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Hoover Honed and *Micro-Velvet* are Hoover trademarks.
*TEFLON is a DuPont trademark.

FOR *Accurate Parts and Faster Assembly*

ZINC DIE CASTINGS ARE BEST

20 YEARS OF SUCCESSFUL EXPERIENCE with ***ZAMAK*** alloy die castings have led Neptune Meter Company engineers to use 40 or more such parts in some models of their AUTO-STOP PRINT-O-METER REGISTER.

This direct-reading register for liquid meters is a perfect example of complexity made simple by the use of pressure-cast zinc alloy. Notice the many as-cast features in these parts: bosses, studs, cored holes, lettering, strengthening ribs and even inserts of other materials cast in place. These parts are ready for assembly with a minimum of machining, and at a saving of production costs.

These assembly advantages resulted from intelligent design. They can be adapted for your products as well — along with the natural durability and corrosion resistance of ***HORSE HEAD® ZAMAK*** die casting alloys.

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street · New York 38, N. Y.

HORSE HEAD PRODUCTS ®

Circle 446 on Page 19

AUDIO DESIGN
December 25, 1958

For Harmony

THAT long-suffering soul, the engineer's wife, was really wound up. "Christmas Day, of all days, you'd think Joe might spend a few hours with his family. But no, his problems at the office can't wait. Now dinner's ready and the kids hungry and impatient, but still no Joe.

"And another thing. The storm windows aren't up yet, the leaves didn't get raked, the gutters haven't been cleaned, and the faucet in the laundry has been leaking since the fourth of July. Myrtle's husband next door keeps their place in tip-top shape, and he's been home all day with the kids. Why, oh why, did I marry an engineer?"

Yes, lady, but Myrtle has so thoroughly domesticated Jerry that his professional development is at a standstill. His appeasement policy is jeopardizing his career just as Joe's drive is jeopardizing his home life.

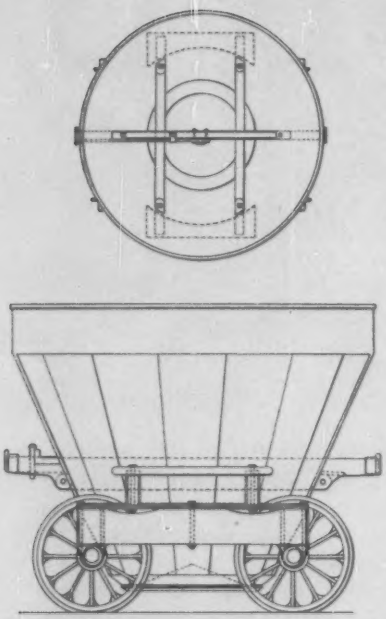
Neither extreme is necessary. Like the rest of us, Joe and Jerry have each been endowed with the same number of hours in a week—168 to be exact. The job demands about 40 hours, a man needn't sleep more than 56 hours, another 32 hours might be needed for eating, bathing and dressing, commuting, etc. That still leaves him 40 hours—as many as he spends on the job—to use more or less as he pleases.

How to allocate these hours is a problem that might respond to an engineering approach. Spare-time activities classify roughly as professional development, social life, and recreation. A scale like an audio spectrum could be constructed ranging all the way from serious professional activity down to plain "goofing off." Bands along the scale would represent the church, community affairs, home life, sports and hobbies, and so forth. Joe and Jerry, obviously, are too monotonic—have too limited a response range.

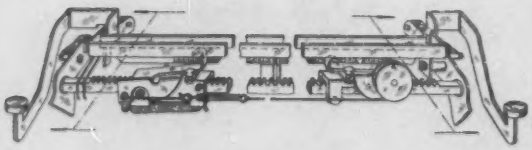
The answer is to apply the necessary boost and attenuation at proper points in the scale. That is how the audio engineer creates high fidelity. And perhaps the Joes and Jerrys can adjust their own circuits in similar fashion to create more harmonious lives.

Colin Carmichael

EDITOR



Early ore-car design patented in 1847. Cone-shaped hopper of circular cross section was employed to provide even distribution of load with low center of gravity. Later designs by other manufacturers employed the same general construction but used an octagonal hopper shape. In an infringement action that was carried to the U. S. Supreme Court for final decision, the decree in favor of the original inventor established his right to claim every form in which his invention was copied. This decision established the "doctrine of equivalents" which has been widely followed as a precedent in such cases by the courts.



Patented typewriter-margin regulator involved in a court action for infringement. Company to whom patent was assigned brought suit against another manufacturer for producing a similar device with only minor variations to avoid infringement. In its decision, holding the second device an infringement, the court extended the doctrine of equivalents and enlarged the scope of the original patent claims "to prevent an infringer from stealing the benefit of the invention."

When is one invention a duplicate of another one?

COPYING or duplicating patented inventions is prohibited by the patent law. But just what is a duplication? In answering this question, which is frequently a major issue in patent infringement suits, the courts rely on a number of well-established precedents and rules.

If duplication is apparent from a comparison of patent claims, infringement is immediately established and the courts will go no further. But the courts also recognize that to permit imitation of a patented invention by another device which does not copy every literal detail, "would be to convert the protection of the patent grant into a hollow and useless thing. Such a limitation would leave room for—indeed encourage—the unscrupulous copyist to make unimportant and insubstantial changes and substitutions in the patent which, though adding nothing, would be enough to take the copied matter outside the claim, and hence outside the reach of the law."[1]

ORIGIN of this statement was a recent United States Supreme Court ruling, upholding the decision of a trial court that certain flux claims of a patented welding process were infringed.[1]

The patented process made use of a combination of magnesium silicate (an alkaline earth metal) and calcium fluoride as the welding medium. Another similar process substituted manganese silicate (not an alkaline earth metal) for the magnesium. The point in question was whether the substitution was a change sufficient to make the "doctrine of equivalents" inapplicable or whether it was so in-

[1]References are tabulated at end of article.

Here are the rules followed by the courts in resolving the knotty question of

Patent Equivalents

By ALBERT WOODRUFF GRAY
Forest Hills, New York

substantial that the trial court's invocation of the doctrine was justified.

After studying the claims of both processes, the court heard testimony from technical experts and witnessed actual welding demonstrations using both compositions. Testimony and demonstration showed that in all respects the compositions were alike, the mechanical methods by which they were employed were similar, and both produced the same kind and quality of weld. In the eyes of the trial court, the substitution was so insubstantial, in view of the technology and prior art, that infringement was held under the doctrine of equivalents.

In affirming the decision, the Supreme Court said: ". . . the trial court could properly infer that the accused flux is the result of imitation rather than experimentation or invention. Though infringement was not literal, the changes which avoid literal infringement are colorable only."

What constitutes equivalence must be determined against the context of the patent, the prior art, and particular circumstances of the case. According to the court, "Equivalence in the patent law is not the prisoner of a formula and is not an absolute to be considered in a vacuum. It does not require complete identity for every purpose and in every respect. In determining equivalents, things equal to the same thing may not be equal to each other and, by the same token, things for most purposes different, may sometimes be equivalents.

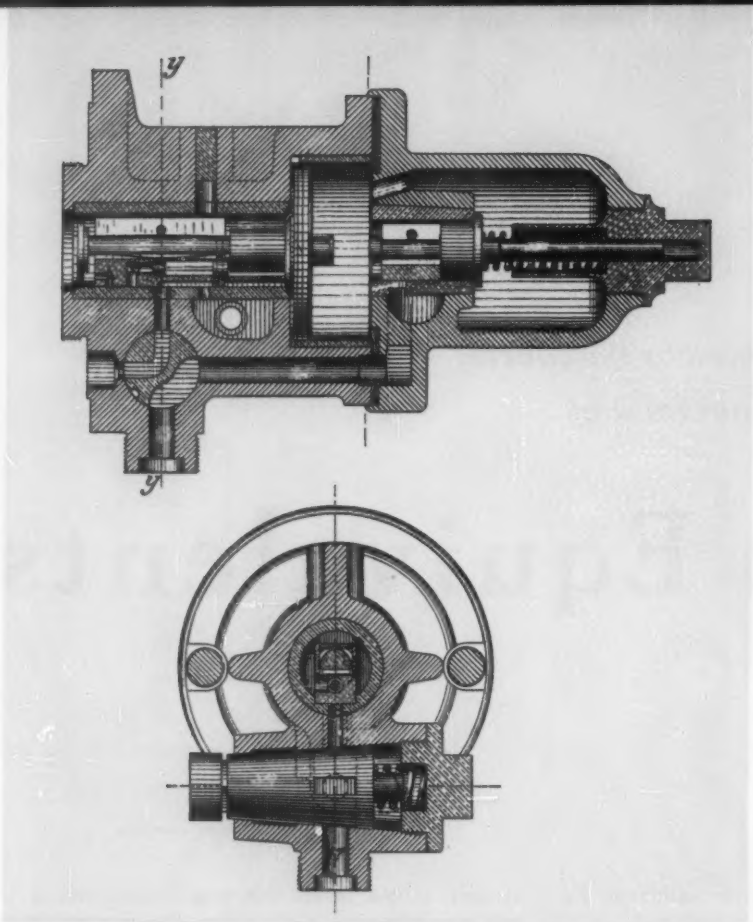
"Consideration must be given to the purpose for which an ingredient is used in a patent, the qualities it has when combined with the other ingredients, and the function which it is intended to perform. An important factor is whether persons reasonably skilled in the art would have known of the interchangeability of an ingredient not contained in the patent with one that was."

The court said that it was difficult to conceive of a case more appropriate for application of the doctrine since all evidence of infringement was backed by testimony of experts. A finding of equivalence is merely a determination of fact, and proof can be made in any form. In its earlier development, the doctrine was usually applied in cases involving devices where there was equivalence in mechanical components. Today the doctrine is applied to mechanical or chemical equivalents.

OVER a century ago, a patent was granted for ". . . a car for the transportation of coal, . . . in the form of a frustum of a cone, . . . whereby the force exerted by the weight of the load presses equally in all directions and does not tend to change the form thereof, so that every part resists its equal proportion and by which the lower part is so reduced as to pass down within the truck frame and between the axles to lower the center of gravity of the load without diminishing the capacity of the car, . . ."

Later, when this general principle of car construction was adopted by others, who used an octagonal rather than a cylindrical car shape, suit was brought for infringement. That court decision established the doctrine of equivalents.[2]

"The exclusive right to the thing patented is not secured, if the public are at liberty to make substantial copies of it, following its form or proportions," asserted the court. "And therefore, the pat-



Patent Equivalents

Early air-brake design patented by G. Westinghouse Jr. in 1887. This patent was the basis of an infringement action against another brake design operated by a valve that was similar to a feature on Westinghouse's invention. Although a broader interpretation of the patent claims of the Westinghouse invention was permitted because of its "pioneer" status, the court held there was no infringement. "That two machines produce the same effect will not justify the assertion that they are substantially the same or that the devices used are, therefore, mere equivalents for those of the other."

entee, having described his invention and shown its principles, and claimed it in that form which most perfectly embodies it, is, in contemplation of the law, deemed to claim every form in which his invention may be copied, unless he manifests an intention to disclaim some of those forms."

To prevent an infringer from stealing the benefit of an invention, an inventor may invoke the doctrine of equivalents against the producer of a device which performs substantially the same function in the same way to obtain the same result.

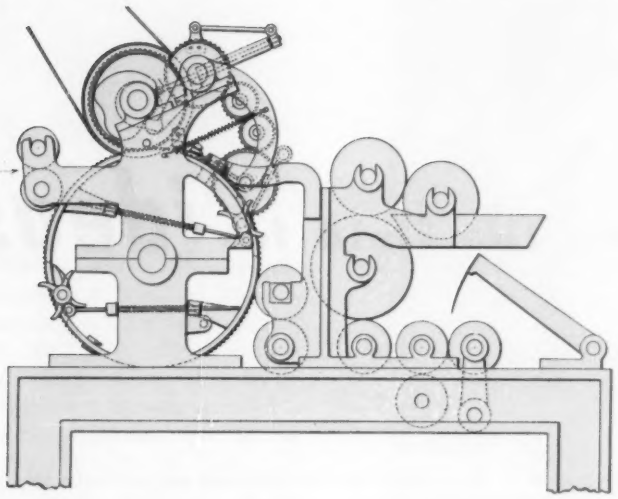
However, this doctrine does not always work in favor of the original inventor but is sometimes used against him. For example, where a device is so far changed in principle from a patented article that it performs the same or a similar function in a substantially different way, but nevertheless falls within the literal words of the claim, the doctrine may be used to restrict the claim and defeat the inventors action for infringement.

A TYPEWRITER manufacturer was charged with making minor variations on a patented device as a means of evading infringement.[3] In extending the doctrine of equivalents against the manufacturer, the court said: "A patent is like any other legal instrument, but it is peculiar in this, that after all aids to interpretation have been exhausted and the scope of the claims has been enlarged as far as the words can be stretched, on proper occasions courts make them cover more than their meaning will bear.

"If they apply the law with inexorable rigidity they would never do this but would remit the patentee to his remedy of reissue, and that is what they frequently do. Not always, however, for at times they resort to the 'doctrine of equivalents' to temper unsparing logic and prevent an infringer from stealing the benefit of the invention.

"No doubt this is, strictly speaking, an anomaly but it is one which the courts have frankly fostered and accepted almost from the beginning. All patents are entitled to its benefit to an extent, measured on the one hand by their contribution to the art and on the other by the degree to which it is necessary to depart from the meaning to reach a just result."

IN dealing with basic or "pioneer" inventions, the courts permit a broader interpretation of patents under the doctrine of equivalents than for patents of mere improvements of existing inventions. Of



Paper-bag machine patented in 1896. This patent was the subject of a famous U. S. Supreme Court decision in which the doctrine of equivalents and the extent of its application were summarized. Although not a pioneer invention, the machine was judged important enough to warrant a broad range of latitude in interpreting the scope of its patent claims.

the term "pioneer," a court said:

"This word, although used somewhat loosely, is commonly understood to denote a patent covering a function never before performed, a wholly novel device, or one of such novelty and importance as to mark a distinct step in the progress of the art as distinguished from a mere improvement or perfection of what had been before. Most conspicuous examples of such patents are: The one to Howe of the sewing machine; to Morse of the electrical telegraph; and to Bell of the telephone . . ."

When a suit was brought many years ago for infringement of an airbrake patent,[4] it appeared that another brake design operated with a valve that was similar to a feature on the earlier invention. However, the court held that the patent was not infringed.

In pointing out the differences between the valves in question, the court said that an infringement involves substantial identity regardless of how the identity is described. It stated further that "the argument for infringement should not assume that every combination of components in a device that produces the same effect is necessarily an equivalent for another combination used for the same purpose.

"When a device differs only in form or rearrangement of elements from those of a patented device, infringement is held even though the device is an improvement. But after all, even if the patent for a machine be a pioneer, the alleged infringer must have done something more than reach the same result. He must have reached it by substantially the same or similar means or the rule that the function of a machine cannot be patented is of no practical value. To say that the patentee of a pioneer invention for a new mechanism is entitled to every mechanical device which produces the same result is to hold, in other language, that he is entitled to patent his function. Mere variations of form may be disregarded, but the substance of the invention must be there."

The court then went on to say that an infringement "is a copy of the thing described in the specification of the patentee, either without variation, or with such variations as are consistent with its being in substance the same thing. If the invention of the patentee be a machine, it will be infringed by a machine which incorporates in its structure an operation the substance of the invention; that is, by an arrangement of mechanism which performs the same service or produces the same effect in the same way, or substantially the same way . . . That two machines produce the same effect will not justify the assertion that they are substantially the same or that the devices used are, therefore, mere equivalents for those of the other."

IN a decision of the Supreme Court over half a century ago, the doctrine of equivalents and the extent of its application were summarized:[5]

"The range of equivalents depends upon the extent and nature of the invention. If the invention is broad or primary in its character, the range of equivalents will be correspondingly broad, under the liberal construction which the courts give to such inventions."

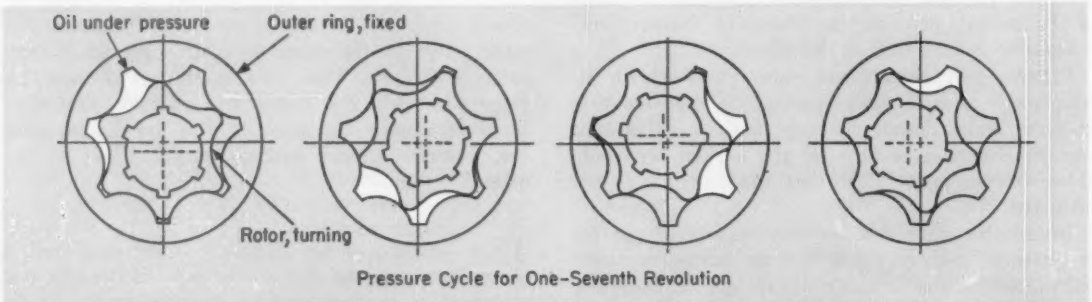
Quoting from another case, the court continued "It is well settled that a greater degree of liberality and a wider range of equivalents are permitted where the patent is of a pioneer character than when the invention is simply an improvement, may be the last and successful step, in the art theretofore partially developed by other inventors in the same field."

REFERENCES

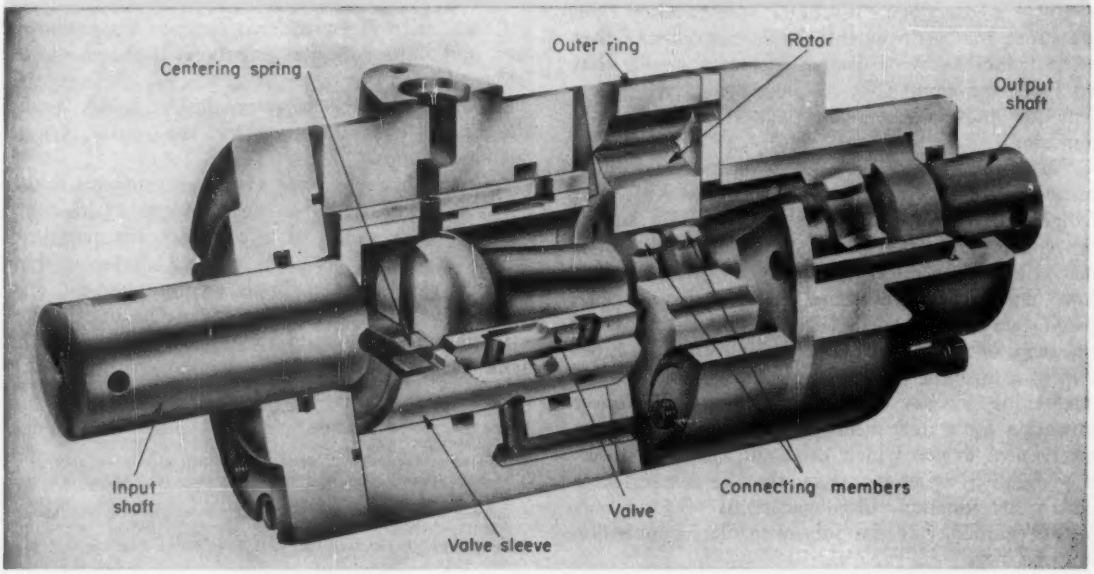
1. Graver Tank & Mfg. Co. v. Linde Air Products Co., 339 *U.S.* 605, May 29, 1950.
2. Winans v. Denmead, 15 *How.* (*U.S.*) 329, December, 1853
3. Royal Typewriter Co. v. Remington Rand, 168 *Fed.* 2d 691, May 21, 1948.
4. Boyden Power Brake Co. v. Westinghouse, 170 *U.S.* 537, May 9, 1898.
5. Continental Paper Bag Co. v. Eastern Paper Bag Co., 210 *U.S.* 405, June 1, 1908.

scanning the field for *ideas*

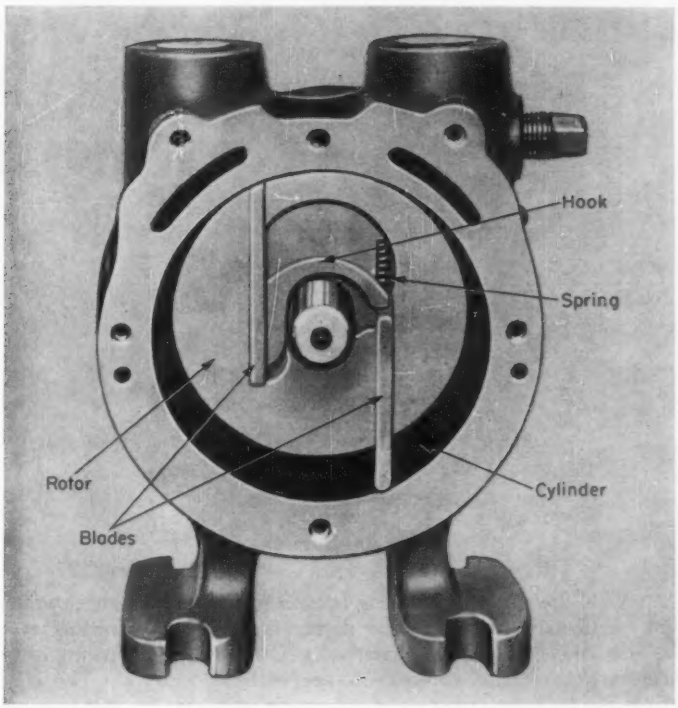
Torque amplification without speed reduction is accomplished hydraulically by a gear-and-rotor mechanism. In this torque-multiplying arrangement, a floating gear-type rotor revolves within a mating fixed outer ring having one additional tooth space. Rotation of the input drive shaft under unbalanced torque loads compresses a centering-spring assembly, turning a control-valve sleeve. The sleeve introduces pressurized oil into the proper chambers to step up rotor torque output. The rotor is connected to the input and output shafts by a pair of splined swivel members which rotate in a conical path. As long as the output shaft requires a higher torque than applied to the input shaft, the centering springs are compressed permitting oil to enter the rotor chamber. When the input and output torques are balanced, the springs recover and the oil bypasses the rotor, providing a straight mechanical drive. The principle is employed in a torque booster developed by the Char-Lynn Co.



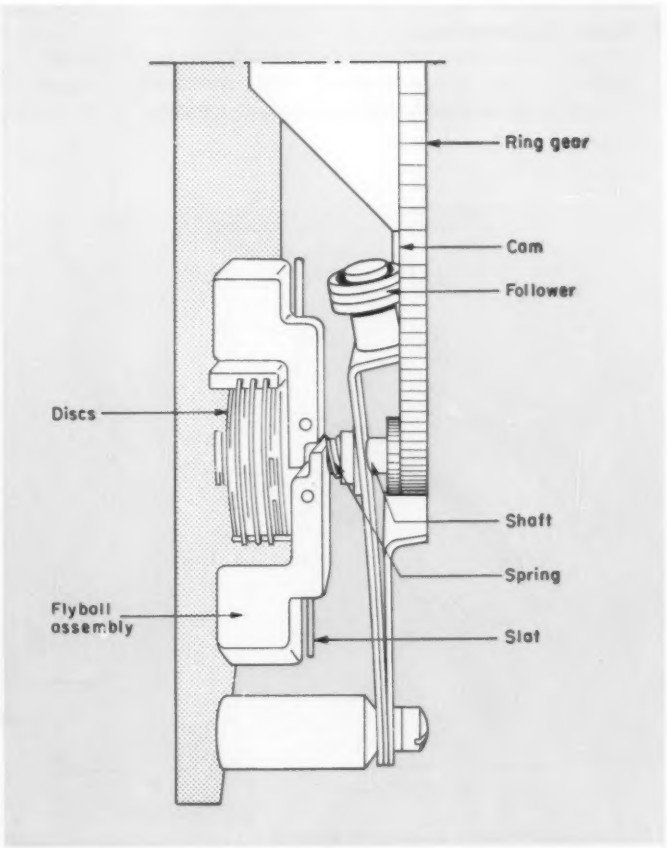
Pressure Cycle for One-Seventh Revolution



Offset rotor blades act against each other to maintain constant cylinder-wall contact and sealing at low as well as high speeds. Mounted in an eccentric rotor, a hook attached to one blade rides on top of an opposing spring-loaded blade. Under rotation, depression of one blade into the rotor forces the second blade against cylinder wall to maintain two blade contact independent of centrifugal action. Design was developed by Leiman Bros. Inc.



Two-speed governing is achieved by cam control of flyball action on a multiple-disc friction brake. When the follower rides on the high level of the cam, a spring on the governor shaft is partially compressed against a slat. This prevents flyballs, which are connected to the shaft, from exerting pressure on discs until sufficient centrifugal force is achieved to further compress spring. When flyballs exert pressure, the rotating discs are squeezed against semifixed discs to provide braking. When the follower is on the low level of the cam, the spring is not compressed and flyballs are free to exert full braking action at a lower centrifugal force. This principle is used in the Fischer and Porter digital demand recorder.



Friction-Clutch Transmissions Part 4

How To Cope with

EVEN the smoothest-looking friction surfaces are sufficiently rough to be determining factors in the life of friction materials. Concentrated loads at high points cause flash temperatures well above the bulk temperatures of adjacent clutch components. By analyses, summaries, and examples, this final article of the series tells how to minimize harmful flash effects, and how to determine and control clutch-member bulk temperatures.

Flash Temperatures

Earlier in this article series, it was mentioned that very high values of transient surface temperature occur at the interface between two sliding bodies, and that these temperature flashes occur at points of intimate contact between the two surfaces.

The effective or *microscopic* contact between the two surfaces is confined to surface high-spots. It can be shown that the relationship between the effective and the nominal or *macroscopic* area of contact is $A_F/A_f = p/p_m$.

If contact occurs at n spots, and if these spots are assumed to be round in shape and equal in size, $A_F = \pi r^2 n$.

When relative motion exists between the surfaces, a number of bright spots appear at the rubbing interface. The position of these spots changes rapidly as points of intimate contact wear away and new

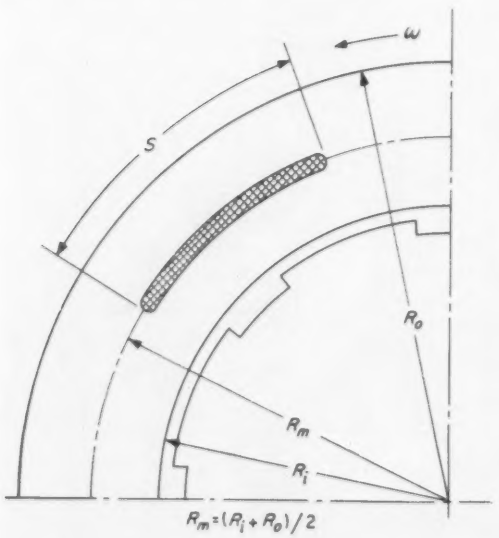


Fig. 24—Basic clutch-plate features

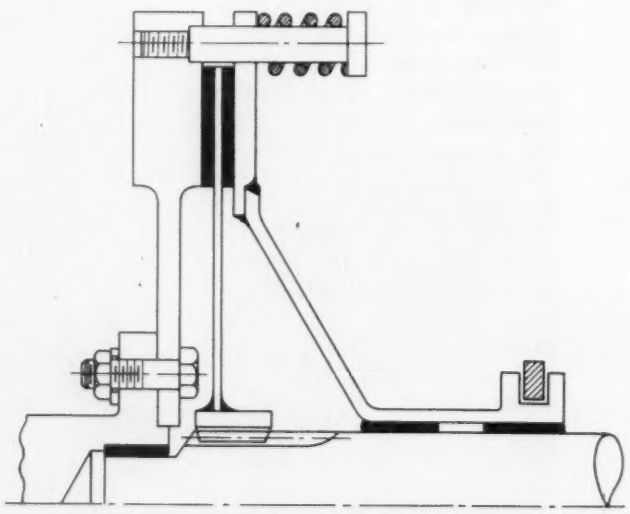


Fig. 25—Representative assembly in which heat is conducted through members, then directly to environment by forced convection

the TEMPERATURE PROBLEM

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ones come into contact. In Fig. 24, which represents a portion of a clutch plate, let S be the distance covered by such an isolated hot-spot in time t_s. which is very small. Then $t_s = S/\omega R_m$. Also, let $S \propto r$.

For simplicity, consider a clutch with only one frictional surface. The rate at which heat enters each spot is $q_r = \delta T_\omega/\pi r^2 n$.

Due to the fact that t_s is very small, q_r will remain sensibly constant. Also, the effect of heat reflection from the other side of the plate can be neglected. This assumption allows the use of the simplest expression for surface temperature, which is derived for the case of a semi-infinite solid receiving heat at a constant rate:

$$\theta_f(t) \propto \sqrt{R_1/C_1}\, q_r \sqrt{t_c} \qquad (90)$$

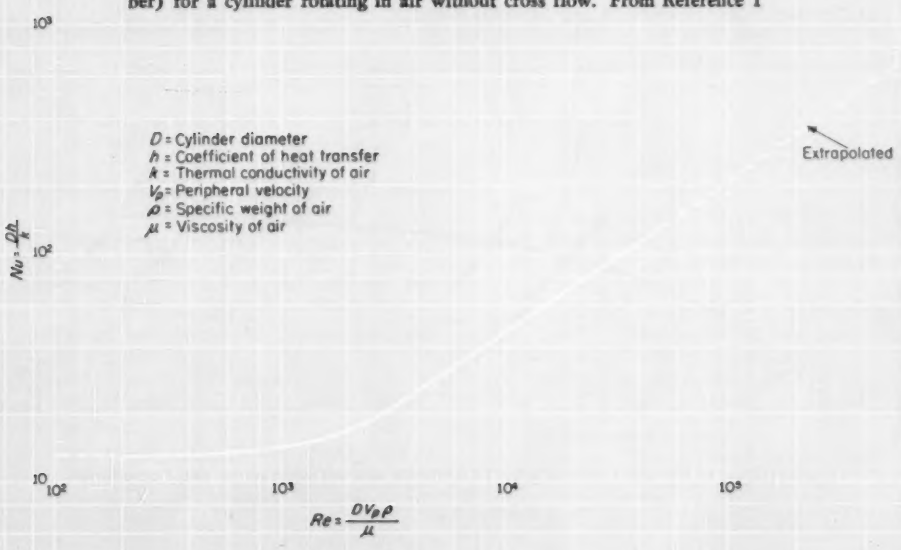
Assume $A_p \propto R_m^2$ and $T = \mu p A_p R_m$. Substitutions in Equation 90 from these relations and those stated earlier yield

$$\theta_f(t) \propto \sqrt{\frac{R_1}{C_1}} \left(\frac{\mu p_m^{3/4} R_m p^{1/4} \omega^{1/2}}{n^{1/4}} \right) \qquad (91)$$

Although obtained with some sweeping assumptions, Equation 91 shows how to decrease the value of flash temperatures occurring at the areas of intimate contact. The same points should be considered when selecting friction material and clutch-plate size. They are:

1. Soft friction materials having good surface conform-

Fig. 26—Correlation of Nu (Nusselt number) vs. Re (Reynolds number) for a cylinder rotating in air without cross flow. From Reference 1



ability are preferred.

2. Coefficient of friction should be low, but high values of μ are preferred to minimize clutch size. These conflicting recommendations can be compromised by a material having sharp fade characteristics at high temperatures.
3. Contact between mating plates should be as uniform as possible. That is, the number of contact spots, n, should be as large as possible.
4. For a clutch of given A_f, R_m should be small. This statement is counter to the observation that large R_m provides proportionately large frictional torque. Compromise decisions should take into account both flash temperatures and the value of the frictional torque desired.

To a certain extent, the foregoing analysis explains why substitution of hard sintered-bronze plates for other plates coated with such materials as cork or wood flour and asbestos mixtures does not always solve high-temperature problems in a poorly designed clutch. Sintered bronze has higher thermal conductivity than cork, and this results in low surface temperature. But this advantage is offset by high values of surface temperature flashes if contact between the rubbing plates is not uniform. Therefore, when metallic friction materials are used, great care should be taken in the preparation and finish of the working surfaces.

Bulk Temperature of Clutch Assembly

When continuous cycling is a normal operating condition of a friction clutch, the average temperature of the assembly during operation must be determined. Heat transfer by convection and radiation, rather than conduction, is the basis for investigation and calculation.

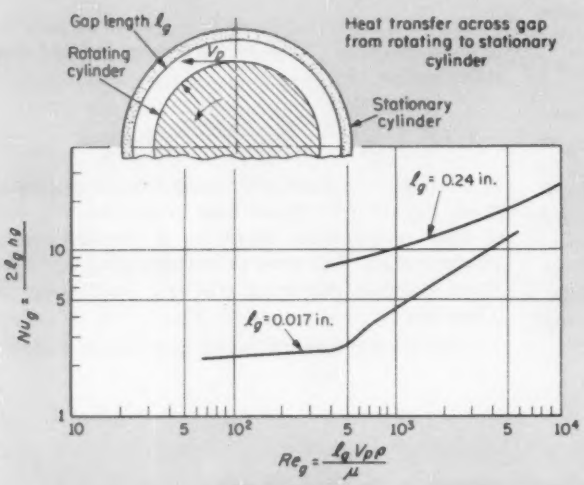


Fig. 27—Gap Nusselt number vs. gap Reynolds number without axial flow in the gap. From Ref. 1.

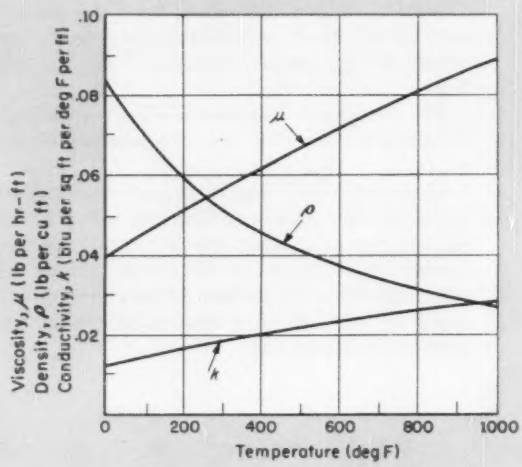


Fig. 28—Properties of air

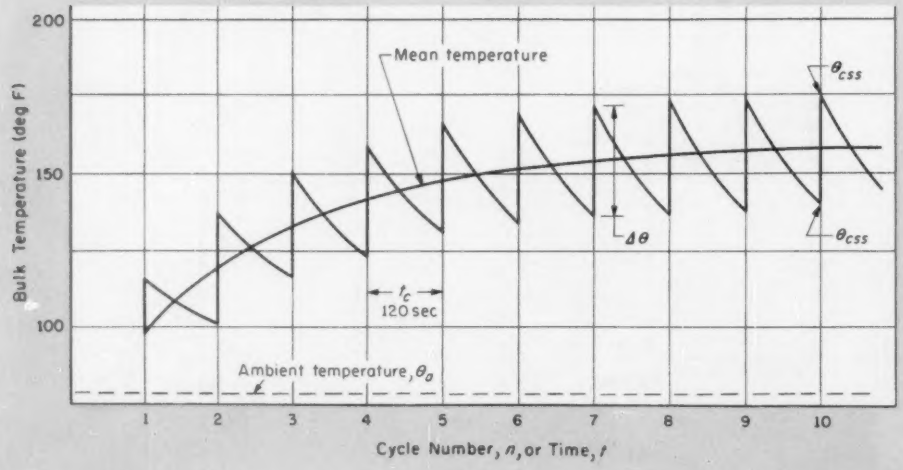


Fig. 29—Bulk-temperature variation for clutch in Fig. 25

Accuracy of results is qualified by the following considerations:

1. Although most clutch assemblies are similar in geometric outside appearance, details of design vary widely. These differences may influence heat transfer considerably.
2. Heat transfer data are not available for certain conditions under which the clutch is required to perform. Typical conditions are: Large diameter-to-length ratio, oil-mist atmosphere, and end effects.
3. Errors occur when equations and methods applicable to simple and idealized cases are used to describe complicated systems. The main reason is that many so-called "constants" are seldom truly constant. Also, some effects considered negligible in idealized cases may become quite prominent in an actual system.

However, to estimate whether a proposed design is feasible, approximate methods aided by previous experience are usually preferred to either an outright guess or tedious and time-consuming computations. Ultimately, in situations of this nature, designs must be proof-tested by physical experiment.

There are two ways to estimate the bulk temperature of a clutch, depending on its construction. One method employs Newton's law of cooling. The other does not.

Forced-Convection Methods: Fig. 25 illustrates a clutch in which heat generated at rubbing surfaces is transmitted directly by conduction through a homogeneous material to the outer surfaces, and from there transferred to the environment by forced convection. Under these conditions Newton's law of cooling may be used. It must be remembered, however, that this method is strictly correct only when the following conditions are satisfied:

1. Temperature everywhere within the body, including the surface, is the same at any instant.
2. Surface coefficient of heat transfer is a constant, independent of temperature.

In practice, none of the above really hold, but they are approximated closely if: Thermal conductivity of the material in question is high, temperature does not vary rapidly, relative size of the body is small.

When a solid body of weight W, specific heat c, and exposed surface area A cools slowly from an initial temperature θ_o, the temperature at any subsequent time t is

$$\theta - \theta_a = (\theta_o - \theta_a)e^{-\alpha t} \tag{92}$$

and the temperature rise per cycle is

$$\Delta\theta = \theta_o - \theta_c = \delta Q/W_c \tag{93}$$

It is tacitly assumed that the clutch attains the temperature θ_o instantaneously. This is approximately correct when the time during which the clutch is allowed to cool is large in comparison with the time required for the heat to diffuse throughout the bulk of the plates.

If t_c is the equal time interval between successive

Nomenclature

A, A' = Area of body exposed to environment, inside and outside surfaces, respectively, sq ft
A_r = Effective (microscopic) frictional area over which contact actually occurs, sq in.
A_f = Nominal (macroscopic) area of clutch face contact, sq in.
C_1 = $c_1 \rho_1$
c, c_1 = Specific heat; specific heat of steel
E = Rate of energy loss as black-body emission or black-body reflection
h = Surface coefficient of heat transfer, Btu per sq ft per sec per deg F
h_c = Coefficient of heat transfer due to natural or forced convection, Btu per sq ft per sec per deg F
n = Number of spots on which frictional contact actually occurs, also, number of cycles or cycle number
p = Nominal pressure, psi
p_m = Mean yield pressure of the softer of two friction materials, psi
Q, q = Rate of heat dissipation, Btu per cycle, Btu per sec, respectively
q_r = Rate at which heat enters hot spots
R_i, R_m, R_o = Radii of clutch plate; inside, mean, and outside, in.
R_1 = $1/k_1$, where k_1 = thermal conductivity of steel
r = Radius of spots on which frictional contact actually occurs, in.
S = Arc or distance covered by hot-spot in time t_s, in.
T = Torque, lb-in.
t = Time, sec
t_c = Time per cycle, sec
t_o = Time interval between successive clutch applications, sec
t_s = Time for hot spot to cover arc or distance of length S, sec
W = Weight of solid body, lb
α = Ah/Wc
δ = 1.285×10^{-3} = Conversion factor, lb-ft to Btu
ϵ, E_c = Emissivity; combined emissivity
θ_a, θ_{III} = Ambient temperature, deg F
θ_c = Clutch temperature at beginning of slip period or cycle, deg F
$\theta_{css}, \theta_{css}$ = Steady state temperature, at beginning of cycle and end of cycle, respectively, deg F
θ_e = Clutch temperature at end of slip period or cycle, deg F
θ_f = Temperature of friction surface
$\Delta\theta$ = Temperature rise per cycle, deg F
μ = Coefficient of friction
ρ, ρ_1 = Density; density of steel, lb per cu ft
ω = Angular velocity, rad per sec

Subscripts:

I, II, III identify a clutch only, the clutch housing, and the environment, respectively.
12 and 23 identify activity, such as heat transfer, from I to II, and from II to III, respectively.
g pertains to the gap between clutch members I and II

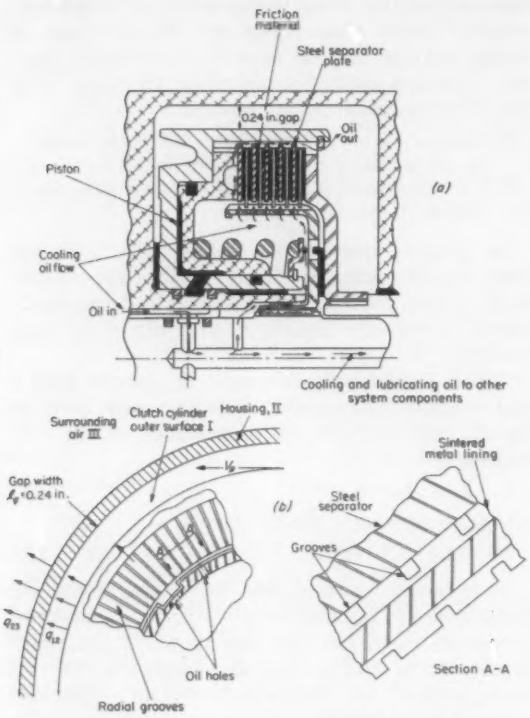


Fig. 30—Representative clutch assembly having provisions for lubrication and friction plate cooling by oil in forced circulation

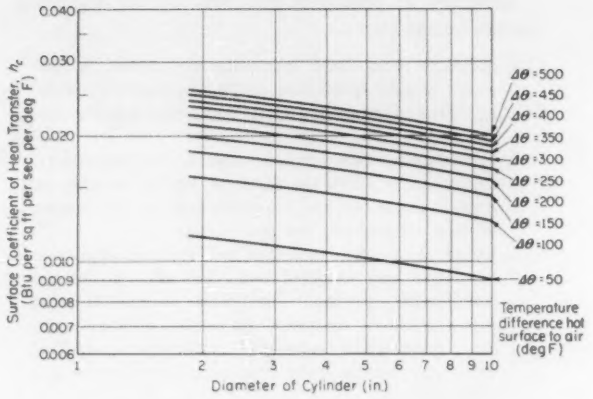


Fig. 31—Surface coefficient of heat transfer vs. cylinder diameter for selected temperature differences, hot surface to surrounding air

applications of the clutch, temperatures are

1st Cycle:

$$\theta_c = \theta_a \quad \text{and} \quad \theta_e = \theta_a + \Delta\theta$$

2nd Cycle:

$$\theta_{c2} = \theta_a + \Delta\theta e^{-at_o}$$

$$\theta_{e2} = \theta_a + \Delta\theta(1 + e^{-at_o})$$

n-th Cycle:

$$\theta_{cn} = \theta_a + \Delta\theta \left[\frac{e^{-(n-1)at_o} - 1}{e^{-at_o} - 1} \right] e^{-at_o}$$

$$\theta_{en} = \theta_a + \Delta\theta \left[\frac{e^{-nat_o} - 1}{e^{-at_o} - 1} \right]$$

The steady state values of θ_{cn} and θ_{en} are obtained by making $n \rightarrow \infty$. Thus:

$$\theta_{css} = \theta_a + \Delta\theta \left[\frac{e^{-at_o}}{1 - e^{-at_o}} \right] \tag{94}$$

$$\theta_{ess} = \theta_a + \Delta\theta \left[\frac{1}{1 - e^{-at_o}} \right] \tag{95}$$

Before Equations 94 and 95 can be used, the value of h must be determined for substitution in the ex-

Table 1—Sample Calculations of Heat Transfer

θ_{II}	E_{II}	E_{III}	$(E_{II} - E_{III})\epsilon_{II}$	$\Delta\theta = \theta_{II} - \theta_{III}$	h_c	$h_c \Delta\theta$	Col. 4 + Col. 7
1	2*	3*	4	5	6†	7	8
150	0.0653	0.0436	0.0195	50	0.0095	0.475	0.4945
250	0.1210	0.0436	0.1025	150	0.0152	2.28	2.3495

* Values obtained from Fig. 32
† Values obtained from Fig. 31

Table 2—Sample Calculations of Heat Transfer*

θ_I	$\frac{\theta_I + \theta_{II}}{2}$	$\frac{\rho}{\mu}$	k	$\text{Re} = 8.36\frac{\rho}{\mu} \times 10^3$	Nu	$h_g = 6.67(\text{Nu})(k) \times 10^{-3}$	$\Delta\theta$	$h_g \Delta\theta$
1	2	3	4	5	6†	7	8	9
232	207	1.15	0.0163	9.61	23.8	0.00258	50	0.129
432	307	0.902	0.0182	7.54	21.1	0.00256	250	0.640

* Given: $A_I/A_{II} = 0.902$; $\epsilon_I = 0.97$; $\epsilon_{II} = 0.90$; $\epsilon_o = 0.88$
† Values obtained from Fig. 27

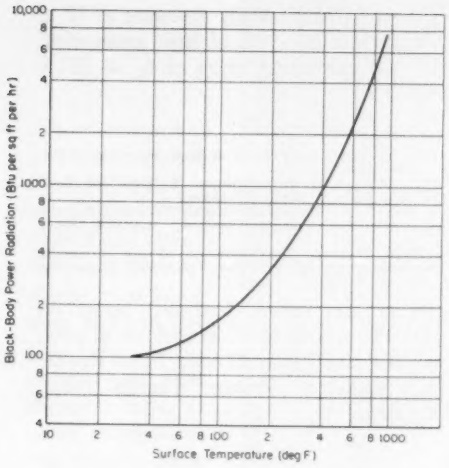


Fig. 32—Power radiated by a black-body surface vs. surface temperature

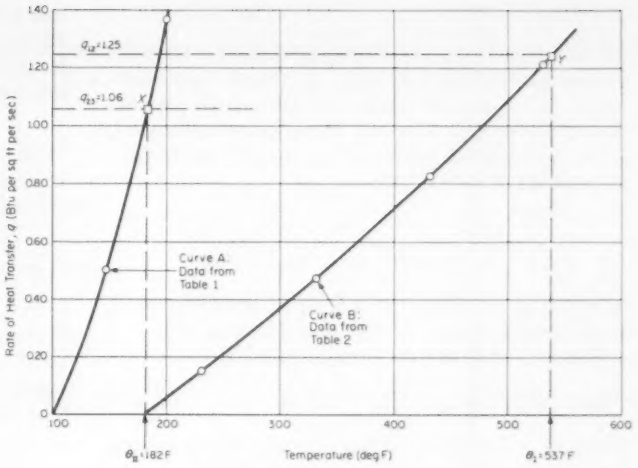

Rate of Heat Transfer, q (Btu per sq ft per sec)
q_{12}=1.25
q_{23}=1.06
Curve A: Data from Table 1
Curve B: Data from Table 2
θ_{II}=182 F
Temperature (deg F)
θ_I=537 F

Fig. 33—Solutions of heat-transfer equations to obtain temperatures of major components in a jacketed, force-cooled clutch

pression which defines α (see Nomenclature). Approximate values can be obtained from Fig. 26 and 27. The data used to draw Fig. 26 were obtained with rotating cylinders in which the length-to-diameter ratio was large, so that end-effects were negligible. This is not quite the case for clutches. Fig. 27 represents the results of experiments designed to establish the heat transfer in rotating electrical machines. Fig. 28 gives those properties of air which are needed to evaluate Reynolds number and Nusselt number.

Fig. 29 shows graphically the results of calculation of the bulk temperature of the clutch shown in Fig. 25 with the following operating and design data: Speed = 1000 rpm, Q = 43.5 Btu per cycle, θ_a = 80 F, W = 8.9 lb, A = 0.67 sq ft, t_c = 120 sec, h = 7.16 × 10^{-3} Btu per sq ft per sec per deg F.

In this case, it is interesting to note that the heat transfer by radiation from the outer surfaces of the clutch amounts to 2 to 3 per cent of the heat removed by forced convection due to clutch rotation.

The other method of evaluating the average temperature of the clutch assembly may be applied in cases where the preceding exponential development based on Newton's law of cooling cannot be used. Discussion is illustrated by a numerical example.

E_I	E_{II}	$(E_I - E_{II})\epsilon_c$	Col. 9 + Col. 12
10	11	12	13
0.1083	0.0806	0.0244	0.153
0.300	0.0806	0.1850	0.825

Consider that the clutch shown in Fig. 30 (disregard the cooling oil for the moment) is intended to be cycled continuously and at a regular time interval of 60 sec. The clutch cylinder rotates at a constant speed of 4000 rpm and is completely enclosed in a cylindrical housing made of good heat-conducting material. The ambient temperature outside the housing is 100 F. Assume further that the average rate of energy dissipation at the rubbing surfaces during the slip period is 0.5 hp per sq in. per cycle. Other knowns are: t_c = 0.8 sec and A_f = 117 sq in. Then, total energy liberated per cycle in the form of heat is 33.1 Btu. In the steady state, the average rate of heat rejection from the clutch assembly is q = 33.1/60 = 0.55 Btu per sec.

The next problem is to determine the average steady-state surface temperature of the clutch cylinder. Generally, it is not advisable to assume that radiant heat transfer is negligible. However, due to high thermal conductivity of the housing material and the fact that the wall is thin, it is safe to assume that temperature drop across the wall is small enough to be neglected.

As seen in Fig. 30, the heat-dissipating areas of the housing and of the clutch cylinder are not equal. Accordingly,

$$q_{12} = q/A_I = 0.55/0.44 = 1.25 \text{ Btu per sec per sq ft}$$

$$q_{23} = q/A_{II} = 0.55/0.52 = 1.06 \text{ Btu per sec per sq ft}$$

where q_{12} = rate of heat flow per sq ft from I to II, q_{23} = rate of heat flow per sq ft from II to III, A_I and A_{II} = heat dissipating areas of clutch cylinder and housing, respectively.

Another expression for q_{12} is

$$q_{12} = h_g(\theta_I - \theta_{II}) + (E_I - E_{II})\epsilon_c \qquad (96)$$

where h_g = heat transfer coefficient in gap g, Btu per sq ft per sec² per deg F; θ_I = surface temp, deg F, of the clutch cylinder; θ_{II} = temperature of

the housing; E_I = rate of energy radiation from the surface of member I at temp θ_1 (black-body emission); E_{II} = rate of energy reflection from member II to member I at temp θ_{II} (black-body reflection); ε_e = combined emissivity of members I and II (due to geometry of system), that is,

$$\varepsilon_e = \frac{\varepsilon_I \, \varepsilon_{II}}{\varepsilon_I(A_I/A_{II}') + \varepsilon_{II} - \varepsilon_I \, \varepsilon_{II}(A_I/A_{II}')}$$

in which ε_I = emissivity of I, ε_{II} = emissivity of II, A_I = outside area of I, A_{II}' = inside area of II.

The rate of heat flow from II to III is

$$q_{23} = h_c(\theta_{II} - \theta_{III}) + (E_{II} - E_{III})\varepsilon_{II} \qquad (97)$$

where h_c = coefficient of heat transfer due to natural (or forced) convection, Btu per sq ft per sec per deg F; θ_{III} = ambient temp, deg F; E_{III} = rate of radiant heat reflection from surroundings.

The value of the coefficient h_c may be obtained from Fig. 31. The coefficient h_g is obtained from Fig. 27. The values of black-body radiant heat transfer are plotted in Fig. 32 in a manner to facilitate computation. Values of ε_I and ε_{II} may be obtained from References 1 and 2.

Since all five quantities h_g, h_c, E_I, E_{II}, and E_{III} are, for any physical configuration, functions of temperatures θ_I, θ_{II}, and θ_{III}, the easiest way to solve Equations 96 and 97 is to proceed as follows:

1. With θ_{III} known, assume a number of values for θ_{II} and calculate corresponding values of q_{23} from Equation 97. Plot these values on a temperature scale as a function of θ_{II}. The resulting graph is shown in Fig. 33, curve *A*. The intersection of this curve (point X) with the horizontal line q_{23} = 1.06 Btu per sq ft per sec determines the value of θ_{II}. All computations can be conveniently set out in tabular form as in Table 1.

2. The same procedure is applied in order to determine the surface temperature of the clutch cylinder, θ_I. Table 2 shows details of computation. The intersection (point *Y*) of curve *B* with the horizontal line, q_{12} = 1.25 Btu per sq ft per sec, determines the surface temperature of the rotating clutch cylinder. In this case it is 537 F.

Since this is the temperature at the surface of the clutch cylinder, the temperature at the rubbing surfaces of the plates during the slip period would be several hundred degrees higher. Therefore, added cooling of the clutch assembly must be provided. In the case of lubricated clutches, Fig. 30, this is accomplished effectively by circulating cool oil through passages which direct the flow at the hot surfaces. The flow of oil should be continuous, and the cooling should be effective prior to, during, and after the slip period. In a heavy-duty clutch, sintered-metal friction plates would probably be used. In this case, Fig. 30*b*, radial grooves are provided easily and inexpensively. At present, no information is available to correlate oil flow with desired end temperature.

An important observation on the preceding calculation is that heat transfer out of the clutch assembly by conduction to other system components has been neglected. This probably amounts to 10 to 15 per cent of the average rate of heat generation. It follows that the calculated value of θ_I = 537 F may be somewhat high.

References

1. Max Jacob—*Heat Transfer*, John Wiley & Sons Inc., New York, Vol. I and II, 1949—1957.
2. William H. McAdams—*Heat Transmission*, McGraw-Hill Book Co., New York, 2nd Edition, 1942, 459 pages.
3. W. M. Kays and I. S. Bjorklund—"Heat Transfer from a Rotating Cylinder With and Without Crossflow," A.S.M.E. Paper No. 56-A-71.
4. Carl Gazley—"Heat Transfer Characteristics of the Horizontal and Axial Flow Between Coaxial Cylinders," A.S.M.E. Paper No. 56-A-128.

Extra copies of the entire, four-part series on "Friction-Clutch Transmissions," bound as a pamphlet, may be obtained for $1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Tips and Techniques

Product Square Root

When the square root of the sum of two squares, $N = \sqrt{a^2 + b^2}$, must be found frequently, this method is helpful. For values of $a \geqq b$, $N = \sqrt{1 + (b/a)^2 a^2}$. Letting $M = \sqrt{1 + (b/a)^2}$, then $N = Ma$. Values of M for various b/a ratios can be calculated and listed in tabular form as shown.

b/a	M	b/a	M	b/a	M	b/a	M
0.01	1.000	0.26	1.033	0.51	1.123	0.76	1.256
.02	1.000	.27	1.036	.52	1.127	.77	1.262
.03	1.000	.28	1.038	.53	1.132	.78	1.268
.04	1.001	.29	1.041	.54	1.136	.79	1.274
.05	1.001	.30	1.044	.55	1.141	.80	1.281
.06	1.002	.31	1.047	.56	1.146	.81	1.287
.07	1.002	.32	1.050	.57	1.151	.82	1.293
.08	1.003	.33	1.053	.58	1.156	.83	1.300
.09	1.004	.34	1.056	.59	1.161	.84	1.306
.10	1.005	.35	1.059	.60	1.166	.85	1.312
.11	1.006	.36	1.063	.61	1.171	.86	1.319
.12	1.007	.37	1.066	.62	1.177	.87	1.325
.13	1.008	.38	1.070	.63	1.182	.88	1.332
.14	1.010	.39	1.073	.64	1.187	.89	1.339
.15	1.011	.40	1.077	.65	1.193	.90	1.345
.16	1.013	.41	1.081	.66	1.198	.91	1.352
.17	1.014	.42	1.085	.67	1.204	.92	1.359
.18	1.016	.43	1.089	.68	1.209	.93	1.366
.19	1.018	.44	1.093	.69	1.215	.94	1.372
.20	1.020	.45	1.097	.70	1.221	.95	1.379
.21	1.022	.46	1.101	.71	1.226	.96	1.386
.22	1.024	.47	1.105	.72	1.232	.97	1.393
.23	1.026	.48	1.109	.73	1.238	.98	1.400
.24	1.028	.49	1.114	.74	1.244	.99	1.407
0.25	1.031	0.50	1.118	0.75	1.250	1.00	1.414

When a square root is required, the value of M for the right b/a ratio is selected from the table and is multiplied by a.—MAX ROSENBERG, *Passaic, N. J.*

Tube Lengths

For quick length measurements of hose, tubing, wire, and sheet metal which have a number of bends and radii on layout drawings, use small-diameter soft solder, bend to conform to shape and length on layout, stretch out solder, and measure over-all length.—ROBERT MCCARTER, *Brooks Rotameter Co., Roslyn, Pa.*

It is no secret that a corrugated sheet resists bending better than a flat sheet. However, the designer must know how deep to design the corrugations—or ribs, flanges, curls, or other strengthening means—for a given imposed load. This article compares a number of simple cross sections to show the relation between shape and strength.

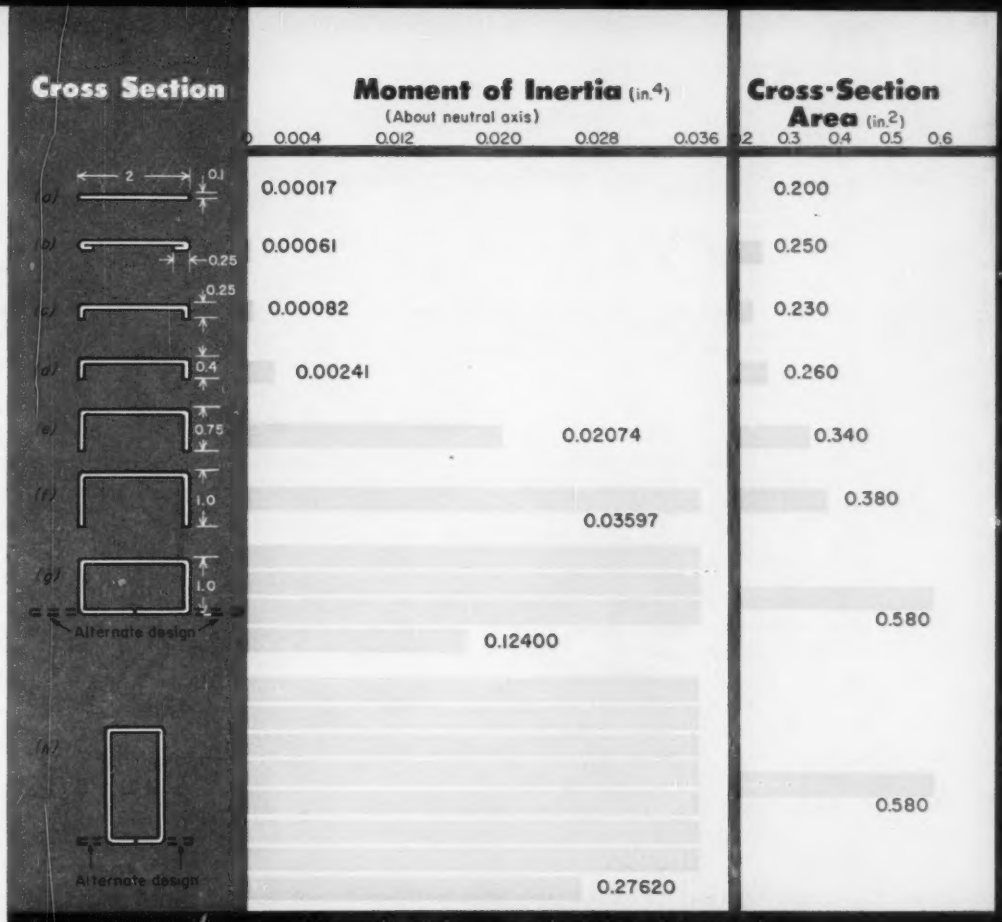


Fig. 1—Moment of inertia is convenient for checking relative strengths of various cross sections. Range of examples in this table involves an area ratio of only 2.5:1, yet strength increases 1581 times

How Strong Are Stampings

A comparison of simple stamped shapes shows how to "beef up" a stamping for rigidity and load-carrying capacity.

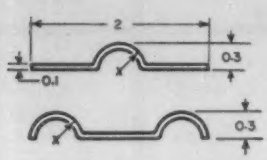
By FEDERICO STRASSER
Santiago, Chile

EMPIRICAL design is quite normal for stampings, with dimensions based on function and the designer's judgment and experience. All too frequently, the only check on how well design and requirement are matched is the testing of samples.

This practice automatically leads to overdesigning as engineers try to avoid service failures. Overdesigning of production parts can lead to excessively high costs. Designers should, whenever practical, cut costs by using the many aids which can add strength and rigidity to a simple part of light metal.

Strengthening means, such as flanges, ribs, and corrugations are well known. However, simple comparisons of the strength inherent in various cross sections can materially assist the designer in avoiding over or underdesigning.

Moment of inertia is a convenient bench mark



	Moment of Inertia ($in.^4$)	Area ($in.^2$)
	0.00124	0.2185
	0.00194	0.237

Fig. 2—Ribs are even more efficient than flanges. Dual-rib design yields 56.5 per cent more strength for 10.8 per cent more material

Fig. 3—Corrugated sheets are common examples of ribs, used as a continuous form

for comparing strengths, since it is proportionate to beam strength or rigidity. Many handbooks give equations for finding moment of inertia of various cross sections and the simple calculations are not time consuming.

Flanges: Strength comparisons for various flanged cross sections (channel shapes) show the large increase in strength gained at little expense in material, Fig. 1. Increase of flange depth from $\frac{1}{8}$ to $\frac{1}{4}$ of the base width of the channel, Fig. 1*c* and *d*, increases strength about 3 times at an expense of only 13 per cent more material. If flange is increased to $\frac{1}{2}$ of base width, Fig. 1*f*, strength is increased (over the $\frac{1}{4}$-width flange) an additional 14 times at an expense of only 46 per cent more material.

Double Flanges: Double flanges can be formed outward (hat section) or inward (box section) without altering strength appreciably, Fig. 1*g* and *h*. The box section, however, will reduce twisting somewhat and permits tack welding the joint to increase rigidity. The moments of inertia for Fig. 1*g* and *h* re-emphasize the importance of locating load-carrying members vertically; the strength ratio is over 2:1.

Ribs: Rounded ribs, either open or closed at the end, are very efficient strengthening devices, Fig. 2. The double-rib section is about equal in cross-section area to the flanged shape in Fig. 1*c*, yet provides almost twice the strength.

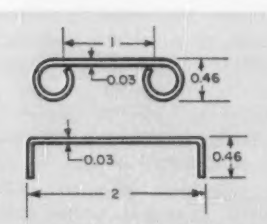
Corrugations, Fig. 3, are merely parallel ribs. Handbook data reveal that 0.032-in. corrugated sheet, with 2.67-in. pitch and 0.875-in. height, has an area of 0.469 in. per foot of width and a moment of inertia of 0.0409 $in.^4$ A flat sheet of equal thickness and area has a moment of inertia of 0.00041 $in.^4$; the corrugated sheet is 100 times as strong.

Curling: Since curls, like flanges, can be made only at the edge of a part, it is customary to curl both edges to simplify production and die-making problems. Curled parts, Fig. 4, cannot be compared directly with those in Fig. 1 because 0.1-in. stock is heavy for curling and is thus not typical of actual parts. A curled and a flanged shape are given in Fig. 4, both having about the same over-all dimensions. Comparison of curled and flanged shapes shows a material ratio of 4:3 and a strength ratio of 2:1. Reducing the curl diameter will cut the strength although a popular misconception holds that small-diameter curls are stronger.

Hems: Folding a flange flat, or nearly so, to form a hem produces a neat, smooth, burr-free edge but does little for strength, Fig. 1*b* and *c*. Naturally, the hemmed part is stronger than an unformed part, by a ratio of 3:1, but it is not as strong as a flanged part of the same area.

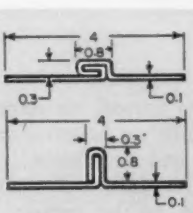
Seams: Not primarily intended to strengthen, seams are used to mechanically join two sheets. Nonetheless, a seam offers considerable strength if it is not folded flat, Fig. 5. Naturally, this strength is at the expense of the mechanical locking of the joint.

Rigidizing: Embossed sheet metal is available in a wide variety of patterns for light-duty decorative applications. The additional strength provided by the process is a bonus. The increase over unworked sheet strength ranges from 10 per cent for carbon steel to about 100 per cent for aluminum.



	Moment of Inertia ($in.^4$)	Area ($in.^2$)
	0.00304	0.117
	0.00151	0.088

Fig. 4—Curled edges are stronger than flanged and present a smooth, burr-free edge. Production, however, may require one more operation since the curl is usually started as a flange



	Moment of Inertia ($in.^4$)	Area ($in.^2$)
	0.01003	0.64
	0.03383	0.64

Fig. 5—Although locking ability is sacrificed, vertical standing seams are 3 times as strong as flattened seams

Design Guide

Quick-Operating Fasteners

By JAMES A. PARKS
Assistant Editor

- Forms • Design Features •
- Materials • Sizes •
- Design Options • Sources •

Quick-Operating Fasteners ... *detailed information*

BASIC types of fastening elements include a number of quick-operating devices developed to speed and simplify manual assembly and disassembly of panels, access doors, and other demountable parts. In form, these fasteners range from simple latches and catches to elaborate quick-opening and special-purpose types based mainly on aircraft requirements. Comparable functions are also offered in certain applications by the various quick-release pins (August 23, 1956 and December 12, 1957 issues of MACHINE DESIGN).

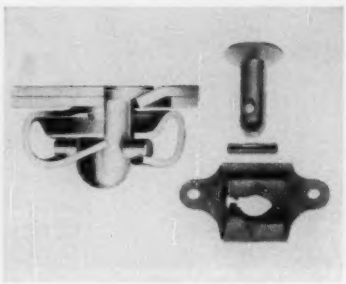
This guide presents detailed information on basic commercial types of quick-operating fasteners in three categories:

1. Rotary-operated types
2. Lever-actuated types
3. Slide-action types

Rotary-operated types depend on a turning or rotary motion, imparted to some actuating member,

ROTARY-

Airloc



Form: Three-piece, quarter-turn fastener: Receptacle, stud, and pin. Pin is rotated past indentations on upper wing surface of receptacle and snaps into locked position. Further turning is prevented by stops on wings of receptacle.

Design Features: In unlocked position, projection on upper wing of receptacle ejects stud into visible position.

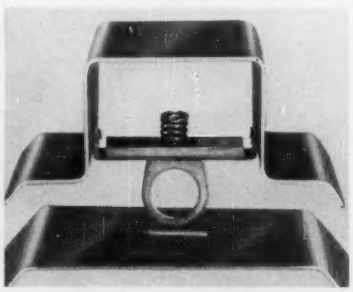
Materials: Receptacle, stud, and pin are steel; grommets, aluminum.

Sizes: Rivet spacing, ½, ¾, 1, and 1⅜ in. Stud diameters, ⅛, 11/64, 17/64 and 5/16-in. Range of panel thickness, 0.30 to 1.50 in.

Design Options: Stud head styles include flush and round with slotted or Phillips recess, and wing type. Modified receptacle designs.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif.

Camloc KM



Form: One-piece, quarter-turn fastener: Coiled spring wrapped around stud with ring-handle which passes through slot in bracket and mating panel. Spring tension holds panels firmly when handle is depressed and rotated one-quarter turn.

Design Features: Installs quickly without riveting or spot welding.

Materials: Steel.

Sizes: Clearance slot, 9/32 by 1 5/16 in. and 11/32 by 1½ in. Overall length 2 and 2¾ in.

Design Options: Rigid or fold down handles. Standard and heavy duty types.

Source: Camloc Fastener Corp., Paramus, N. J.

on 67 types of commercial fasteners for detachable mounting of panels, access doors, and other similar parts

for opening or closing. Included in this classification are the various multiple and partial-turn panel fasteners and latches. Actuating members take the form of knob, handle, screw, nut, or bolt.

Lever-actuated types are operated through a release or locking-lever arrangement. Many of these fasteners are of the drawbolt, catch, cam, and toggle-latch types. Generally, this group contains both direct-action and spring-loaded latches.

Slide-action types are operated by sliding one member over or through another.

Each fastener type in the guide is representative of a basic operating form. Standard and special design modifications or variations offered by manufacturers are listed in the options sections, but are not necessarily all inclusive.

Only materials and sizes supplied as standard are listed. Different standard finishes are also available and most manufacturers offer a range of special finish, material, and size options.

OPERATED TYPES

Camloc Quick-Release

Form: Two-piece, quarter-turn fastener: Receptacle and spring-loaded stud assembly. Receptacle has long cam surface, positive stop, and detent for positive locking as stud is turned one-quarter turn.

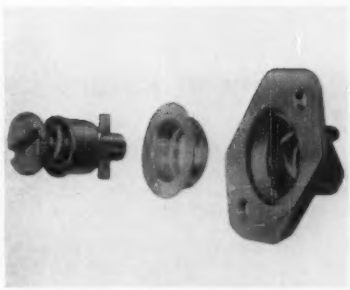
Design Features: In released position, stud is ejected by spring for easy detection. Single stud can be removed without disturbing adjacent studs. Grommets in heavier series prevent panel abrasion. Cam surface provides uniform locking torque.

Materials: Receptacles, silicon bronze, aluminum, and corrosion-resistant steel; studs, carbon and corrosion-resistant steel.

Sizes: Rivet spacing, ¾, 1, and 1⅜ in. Stud diameter, ¼ in.

Design Options: Stud head styles include slotted, winged, knurled, and Phillips recess. Receptacle sealing cup. Lanyard type stud assembly. Modified receptacle designs.

Source: Camloc Fastener Corp., Paramus, N. J.



Dual-Lock

Form: Two-piece, partial-turn cam latch: Lock mechanism and pin striker. Draw-to locking action is provided by off-center cam which actuates latch hook. Full-open and closed positions are obtained by trigger mechanism operated through projections on cam. Trigger is positioned by female engaging pin.

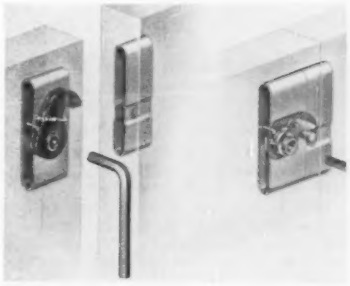
Design Features: Positive locking is assured by double-acting mechanism. High-load capacity. Operated with Allen wrench.

Materials: Alloy steel.

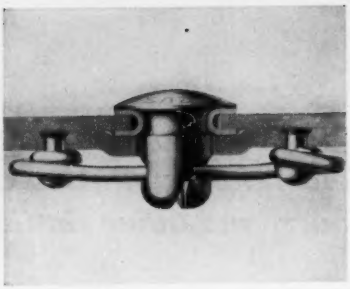
Sizes: Envelope for lock mechanism, 3½ by 3 11/16 by ⅝ in. Various strike sizes.

Design Options: Flush or surface mounting types.

Source: Simmons Fastener Corp., Albany, N. Y.



Dzus Spiral Cam



Form: Quarter-turn fastener: Stud with spiral cam and mating-spring member. Turning stud a quarter-turn causes spiral cam to engage wire element, compressing spring and seating stud in locked position.

Design Features: In locked position, assembly resists loosening by vibration, yet is quickly opened by a small coin, washer, screwdriver, or special key.

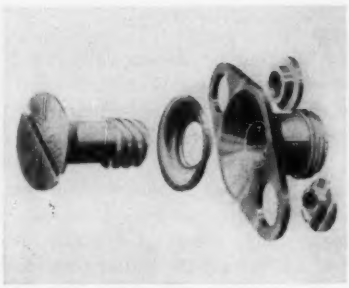
Materials: Studs, heat-treated steel; springs, steel; grommets, aluminum; receptacles, steel.

Sizes: Stud diameters, 3/16 to 7/16 in. Stud lengths, 0.2 to 2.5 in.

Design Options: Variations include multiple-receptacle design (⅜ in. increments) with spring-loaded studs; heavy-duty enclosed receptacle; spring-loaded wing-head type for high-tension locking action; and special spring-member and grommet constructions. Standard head styles include oval, flush, and hex with slotted recess, and wing type.

Source: Dzus Fastener Co. Inc., Babylon, N. Y.

Dzus Universal



Form: Two-piece, partial-turn fastener: Stud with four-lead thread and slotted, threaded receptacle. A wire spring is wrapped around the receptacle to provide locking action. Stud is rotated 270 deg in receptacle to lock assembly. Grommet holds stud captive.

Design Features: Primarily for use in high tensile and shear applications. Resists vibration.

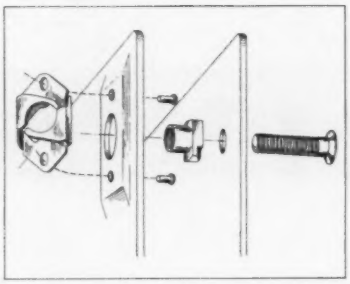
Materials: Receptacle, aluminum alloy; stud and spacer, steel; grommet, aluminum.

Sizes: Stud diameter, 3/16, ¼, and 5/16 in. Rivet spacing ¾ and 1 in. Range of panel thickness, 0 to 1.0 in.

Design Options: Stud head styles include oval, flush, hex, wing, and socket. Modified receptacle and stud-shank designs.

Source: Dzus Fastener Co. Inc., Babylon, N. Y.

ESNA Quick Disconnect



Form: Two-piece, quarter-turn fastener: Receptacle and internally threaded nut. A standard screw inserted in mating panel is threaded into nut. Quarter-turn of screw then locks nut in receptacle.

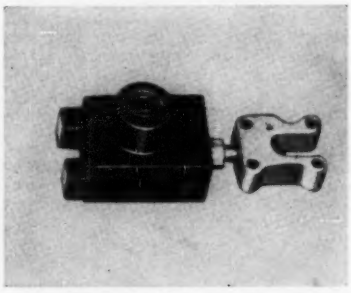
Design Features: Provides rapid connect or disconnect. Screw and nut assembly permits adjustable tightening of panels.

Materials: Receptacle and latch nut, carbon steel.

Sizes: Rivet spacing, ⅞ in. Nut has ¼-20 coarse thread, class 3B.

Source: Elastic Stop Nut Corp. of America, Union, N. J.

Hartwell Rotary Latches



Form: Two-piece, partial-turn latch: Rotary cam-hook assembly and eye-bolt. Eye-bolt is engaged in the cam-hook assembly and half turn of rotary cam engages eye.

Design Features: Axial adjustment of 0.30 in. is provided by eye-bolt. Indicator signifies latched or unlatched condition. Positive locking. Eye-bolt shank is shear pin between mating surfaces. Axial take-up is provided.

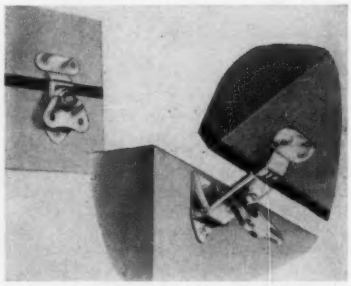
Materials: Housing and bottom plate, aluminum; other parts, steel.

Sizes: Width, 1.35 to 1.38 in.; thickness, 0.99 to 1.56 in. length; 2.15 to 2.35 in., excluding eye-bolt.

Design Options: Various eye-bolt configurations. Actuator styles include ¼-square drive and remote types. Flush and skin-mounting designs.

Source: Hartwell Co., Los Angeles, Calif.

Hinge-Lock



Form: One-piece, half-turn latch: Assembly with hinge-mounted flange. Strap end of assembly is permanently fastened. Half turn of nut draws panels together.

Design Features: Locked fastener lies flat against panel. Designed primarily for cover applications. Positive lock without springs. In released position, panels can be rotated about hinge joints for opening.

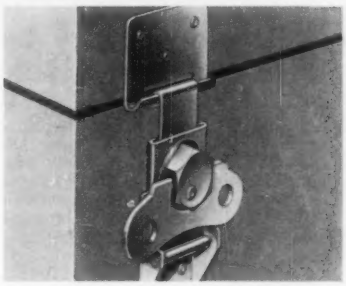
Materials: Alloy steel.

Sizes: Envelopes; 5/8 by 1½ by 2 7/16 in. and 23/32 by 2¾ by 4⅜ in.

Design Options: Actuating member styles include wing, bolt, and screw. Light and medium duty designs.

Source: Simmons Fastener Corp., Albany, N. Y.

Link-Lock



Form: Two-piece, partial-turn latch: Striker plate and hinged locking unit. Hooked strap is engaged in striker and partial turn of nut pulls panels together and locks.

Design Features: Pull-down pressure from 90 to 1500 lb, tension load capacities from 300 to 4000 lb.

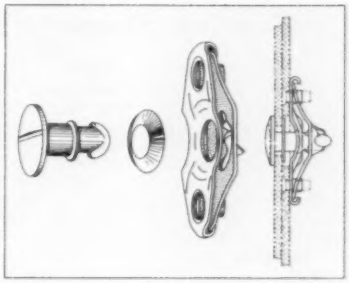
Materials: Alloy steel.

Sizes: Envelopes; 5/8 by 1½ by 2 9/32 in., 23/32 by 2¾ by 3 59/64 in., and 1 by 3½ by 6 in.

Design Options: Various striker designs. Light, medium, and heavy-duty lock designs, with 90 or 180 deg rotation. Actuator member styles include wing and hex nut types. Modified hinge constructions.

Source: Simmons Fastener Corp., Albany, N. Y.

Lion Quarter Turn



Form: Three-piece, quarter-turn fastener: Stud, grommet, and preassembled receptacle. To lock or unlock, stud is rotated quarter turn. In the locked position, stud rests against positive stop.

Design Features: Positive stop prevents over torque. Spring protects against vibration. Floating action tolerates misalignments of 0.070 in. in all directions.

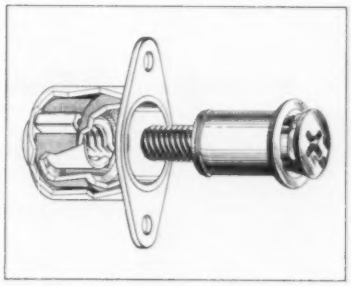
Materials:. Steel.

Sizes: Rivet spacing 1 and ¾ in. Stud diameter, 0.156, 0.195, and 0.290 in. Range of panel thickness, 0.050 to 1.009 in.

Design Options: Light, medium, and heavy-duty designs. Stud head styles include flush, oval, wing, ring, knurled, notched, and key.

Source: Southco Div., South Chester Corp., Lester, Pa.

Monadloc



Form: Two-piece, quarter-turn fastener: Receptacle and preassembled screw and bushing. Quarter turn of screw in receptacle fastens panels together. Take-up of panels is accomplished by tightening screw.

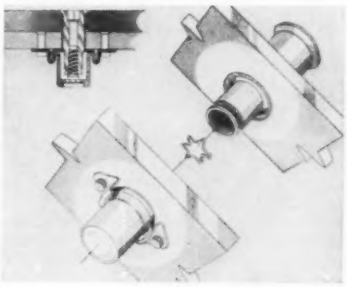
Materials: Carbon and alloy steels.

Sizes: Bushing diameter, ⅜ in. Rivet spacing ⅞ in. Range of panel thickness, 0.140 to 0.924 in.

Design Options: Button head and countersunk bushings. Phillips and Fearson recessed-head screws.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif.

Nutt-Shel Structural



Form: Three-piece, multiple-turn fastener: Internally threaded sleeve bolt, preassembled receptacle, and retaining ring. Sleeve bolt is inserted through panel to engage threaded stud on interior of receptacle and is then rotated to lock assembly.

Design Features: Double-lead thread in sleeve bolt provides rapid connect or disconnect. Tolerates misalignments up to 0.40 in. Sleeve bolt winds itself out of panel when disconnected to eliminate bind. Retaining ring holds sleeve bolt captive. Provides prevailing-torque locking action.

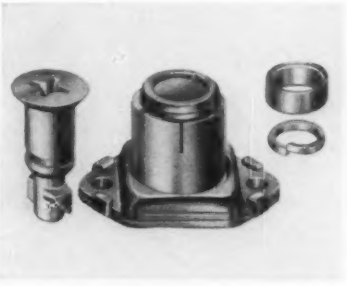
Materials: Alloy steels.

Sizes: Shank diameter, ¼ and ⅜ in. Range of panel thickness, ⅛ to 1 ⅛ in.

Design Options: Modified designs include various receptacle types.

Source: Nutt-Shel Co., Santa Ana, Calif.

Paneloc High Performance



Form: Three-piece, quarter-turn fastener: Stud, retaining ring, and receptacle. Quarter turn of stud in receptacle locks panels in place.

Design Features: High-shear strength. In unlocked position, stud is ejected by spring pressure. Receptacle is adjustable.

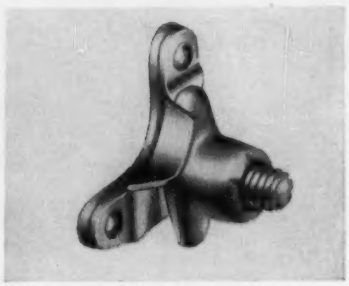
Materials: Steel.

Sizes: Stud diameters, ¼ and 5/16 in. Rivet spacing, ⅞ in. Range of panel thickness, 0.040 to 0.892 in.

Design Options: Stud head styles include flush and oval types. Rigid and floating receptacles.

Source: Scovill Mfg. Co., Waterbury, Conn.

Paneloc Rotary Latch



Form: Four-piece, quarter-turn latch: Latch screw, shim plate, anchor block, and nut. Shim plate and anchor block are fastened to panel. Latch screw is inserted through assembly to engage nut. Nylon bushing in nut provides prevailing torque on screw. Quarter turn of screw locks nut lug against mating panel.

Design Features: Unit assembled on one panel. Screw design permits assembly to be tightened in place after engagement.

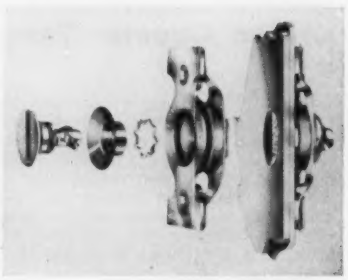
Materials: Steel; nut has nylon insert.

Sizes: Screw diameter, ½-in. Screw to rivet spacing, 0.338 to 0.503 in.

Design Options: Stud head styles include round, flush, and wing.

Source: Scovill Mfg. Co., Waterbury, Conn.

Paneloc Standard



Form: Three-piece, quarter-turn fastener: Stud, retaining ring, and receptacle. Wings integrally forged on shank of stud lock assembly when stud is rotated quarter turn in receptacle.

Design Features: In locked position, assembly resists vibration. No special assembly tools required. Floating receptacle accommodates misalignment.

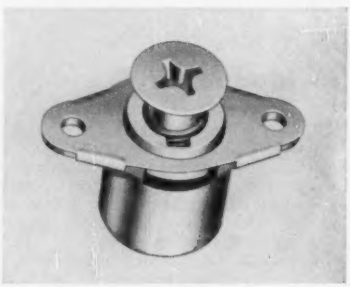
Materials: Retaining ring, steel; receptacle assembly, aluminum and steel.

Sizes: Stud diameters, 5/16 and ⅜ in. Rivet spacing 1 and 1⅜ in. Range of panel thickness, from 0.01 in. up.

Design Options: Light, medium, and heavy-duty designs. Stud head styles include flush, oval, wing, and protruding types. Rigid and floating receptacles. Ejector springs, grommets, and shear washers.

Source: Scovill Mfg. Co., Waterbury, Conn.

Pastushin Full-Shear Stress



Form: Two-piece, quarter-turn fastener: Stud and retainer assembly. Locking pin is centered in stud shank after insertion through panel. Quarter turn of stud in retainer locks assembly.

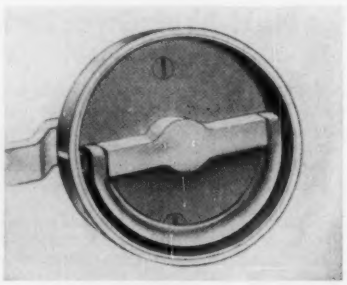
Design Features: Positive lock. Stud is ejected when unlocked. Adaptable to various panel thickness by stud-screw adjustment. Pin retains stud in panel after unlocking.

Materials: Clip and retainer, aluminum; other parts, steel.

Sizes: Stud diameter, ¼ and 5/16 in. Rivet spacing, ⅞ in.

Source: Pastushin Industries Inc., Los Angeles, Calif.

Point Catch



Form: One piece, quarter-turn latch: Handle and cam assembly. Latch fastens at one, two, or three points, and is controlled by one handle. Cams operate latch rods in two and three point types. Cam point engages striker in one and three point types.

Design Features: Positive closing pressure exerted by cam action. Vibration-resistant sealing action. Integral latch and handle arrangement. Latch rods provide adjustment.

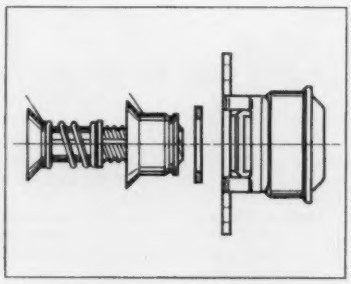
Materials: Steel, aluminum, bronze, and brass depending upon manufacturer.

Sizes: Grip length, 1/16 in. and up, depending upon manufacturer.

Design Options: Various handle, cam, bolt, and mounting designs.

Source: Produced by several manufacturers. Illustrations, courtesy Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

QAF



Form: Two-piece, partial-turn fastener: Preassembled stud and receptacle. Stud is pushed into split nut in receptacle and turned, wedging nut into tapered housing and locking assembly.

Design Features: Spring in stud assembly allows for panel separation. Resists vibration. Tensile load of 4000 lb. Stud protrudes from panel for easy detection until fastened. No special tools required.

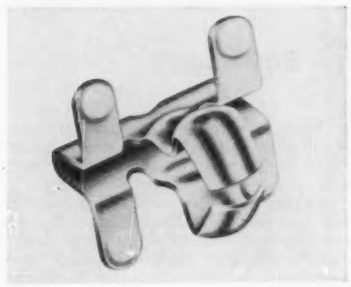
Materials: Steel

Sizes: Rivet spacing ⅞ in. Stud diameter ⅜ in. Grip length, 0.046 to 0.499 in.

Design Options: Stud head styles include flush and protruding types.

Source: Waldes Kohinoor Inc., Long Island City, N. Y.

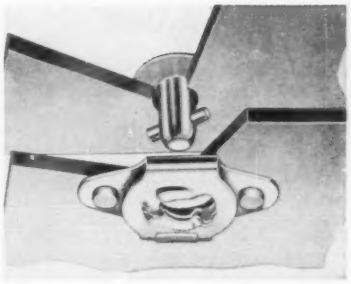
Q-Four



Form: One-piece, quarter-turn fastener. Unit is snapped into a prepared hole in one panel, passed through elongated hole in other panel, and rotated quarter turn to lock.
Design Features: Blind application. Self-retaining.

Materials: Spring steel.
Sizes: Range of panel thickness, 0.065 to 0.225 in.
Design Options: Head styles include dimpled and screwdriver-slot types.
Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.

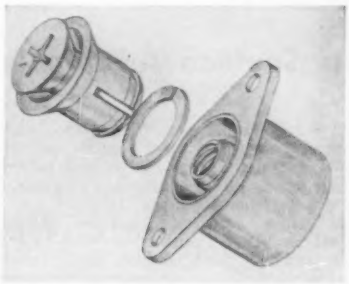
Q-One



Form: Three-piece, quarter-turn fastener: Stud, cross pin, and receptacle. With the stud and pin assembled in one panel, stud is inserted in receptacle and rotated quarter turn to lock panels together.
Design Features: Special tool necessary for pin insertion. Spring action of receptacle provides tight closure and prevents loosening under vibration.
Materials: Steel.

Sizes: Stud diameters, 0.167, ¼, and 5/16 in. Range of panel thickness, 0.02 to 0.650 in.
Design Options: Stud head styles include flush, oval, and ring types. Receptacle mounting hole styles include plain, dimpled, tapped, omitted, and weld-insert types. Side-mounting bracket.
Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.

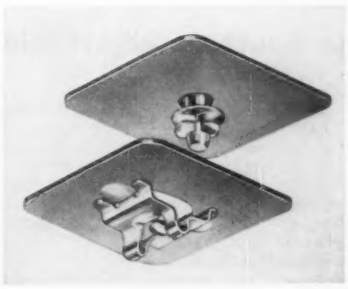
QR



Form: Two-piece, quarter-turn fastener: Stud assembly and floating receptacle. Stud is inserted in receptacle and rotated quarter turn to lock.
Design Features: High strength. Self-aligning. Stud is ejected when not locked. Fixed stop in receptacle holds unit within range of stud. Stud is held captive by retainer.

Materials: Stud-assembly components, alloy steel; receptacle, aluminum.
Sizes: Stud assembly, ⅜-in. diam. Grip length, 0.150 to 1.0 in. Rivet spacing, ⅞ in.
Design Options: Modified unit for dimpled sheet applications.
Source: Calinoy, Div. of Illinois Tool Works, Hawthorne, Calif.

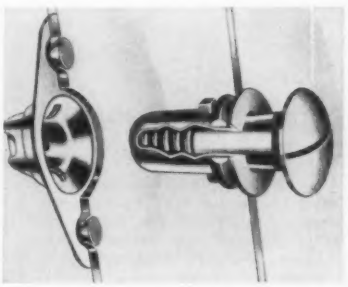
Q-Two



Form: Three-piece, quarter-turn fastener: Stud, washer, and receptacle. Receptacle is snapped into prepared recesses, stud is inserted and rotated quarter turn to lock.
Design Features: Light weight. Requires hole in one panel, and hole with two recesses in other panel. Accommodates misalignment of 1/8 in. Spring action of receptacle provides tight closure.

Materials: Receptacle and retaining washer, spring steel; stud, mild steel.
Sizes: Stud diameter, ¼ in. Range of panel thickness, 0.030 to 0.075 in.
Design Options: Stud head styles include flush and wing types. Receptacle hole shapes include round, oval, and rectangular types.
Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.

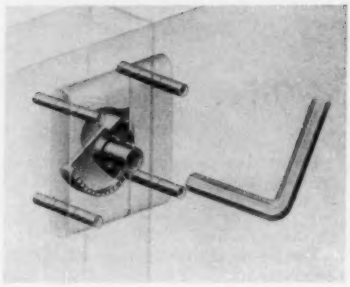
Quick-Lock



Form: Two-piece, quarter-turn fastener: Spring-loaded stud assembly and receptacle. Cam surfaces on receptacle cause stud to clamp panels as it is rotated quarter turn to positive stop.
Design Features: Initial loading is taken up by helical springs in stud assembly. Increased load is carried by stud. Stud is self-ejecting when unlocked. Screw type receptacle permits tightening of panels.

Materials: Steel.
Sizes: Stud diameter, 5/16, ⅜, and 7/16 in. Rivet spacing, ¾, 1, and 1⅜ in. Range of panel thickness, 0.02 to 0.259 in.
Design Options: Stud head styles include flush, oval, and wing types. Receptacle styles include plate and screw types.
Source: Simmons Fastener Corp., Albany, N. Y.

Roto-Lock



Form: Two-piece, partial-turn latch: Cam unit and striker. Tapered, serrated cam in latch meshes with projections on striker when rotated partial turn.

Design Features: Load ratings to 1400-lb tension and 2000-lb shear. In case of misalignment, or if panel closure is obstructed, the latch is locked in a semiopen position. Requires Allen type wrench for operation.

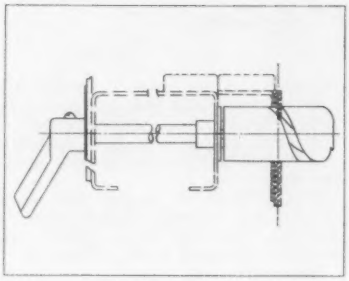
Materials: Alloy steel.

Sizes: Envelope, 3 1/32 by 3 3/8 in. Range of panel thickness, 7/16 and 5/8 in.

Design Options: Flush and surface mounting designs.

Source: Simmons Fastener Corp., Albany, N. Y.

Serve-A-Unit



Form: Five-piece, partial-turn chassis latch: Handle, washer, dowel, lock unit, and bullet-type head. Head with cam groove engages lug in the rear of chassis plate. Lug on head engages lock unit on back of rack. A dowel runs through rack and has head attached to one end, washer and handle to the other. Head engages lug as rack is pushed in, and a 180 deg turn of handle rotates head to lock. Head is kept from turning when lug on back of head locks in lock ring.

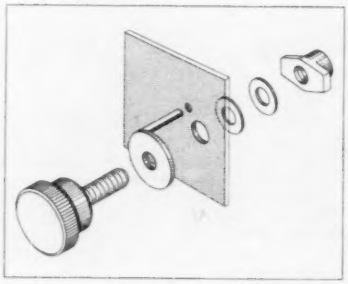
Design Features: Cam groove provides self-alignment. Unit makes plug-in units speedily accessible for checking. Self-ejecting when unlocked.

Materials: Steel.

Sizes: Head diameter, 1-in. Length of dowel, from 1 1/8 in. up.

Source: Alden Products Co., Brockton, Mass.

Southco Adjustable Latch



Form: Three-piece, quarter-turn latch: Stud, pawl, and pawl nut. A quarter-turn of stud rotates nut against adjoining panel and locks assembly. Additional torque tightens panels.

Design Features: Operates without striker plate. Adjustable grip length provided by threaded stud. Panel-thickness variations accommodated by spacer washers.

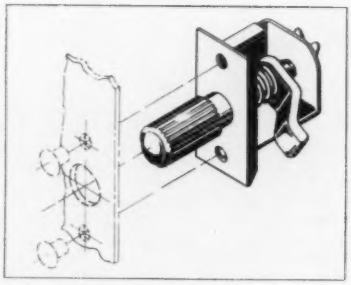
Materials: Steel.

Sizes: Stud diameter, 0.169 and 0.196 in. Max panel thickness, 1.5 in.

Design Options: Stud head styles include wing, round, and knurled-plastic types.

Source: Southco Div., of South Chester Corp., Lester, Pa.

Southco Adjustable Pawl Latch



Form: One-piece, quarter-turn latch. Knob of preassembled unit is passed through one panel from inside. Quarter turn of handle opens or closes latch.

Design Features: Variations in panel thicknesses are accommodated by adjustment on the operating knob. Spring provides tight closure.

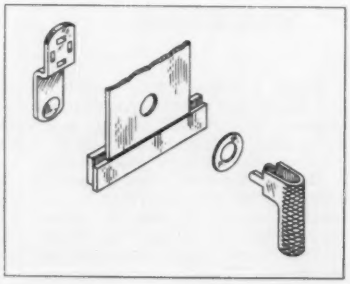
Materials: Steel.

Sizes: Rivet spacing, 13/16, 1 1/4, and 1 7/8 in. Mounting hole diameter, 3/8, 5/8, and 7/8 in. Range of panel thickness, 1/16 to 1 7/8 in.

Design Options: Modified designs include recessed cup, and right and left hand types. Actuator styles include single and double knob, and slotted-flush types.

Source: Southco Div., South Chester Corp., Lester, Pa.

Southco Door Latch



Form: Two-piece, quarter-turn latch: Pawl and actuator. Two parts are fastened together through single hole in panel. Quarter turn engages pawl.

Design Features: Lightweight.

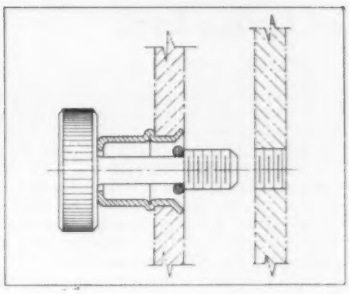
Materials: Carbon steel.

Sizes: Range of panel thickness, 0 to 11/16 in.

Design Options: Actuator styles include handle and screwdriver types.

Source: Southco Div., South Chester Corp., Lester, Pa.

Southco Retractable Screw



Form: Three-piece, captive stud assembly: Plastic O-ring, bushing and threaded stud. Bushing is flanged into panel and stud inserted in over-size hole. Stud engages threaded hole in one panel and is held captive by O-ring.

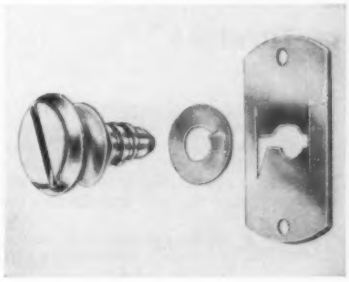
Design Features: Large hole permits stud to "float" for misalignment compensation.

Materials: Stud and bushing, brass; O-ring, plastic.

Sizes: Stud threads, 1/4-20, No. 12-24, No. 10-24, and No. 10-32. Stud length, 1 3/16 in.

Source: Southco Div., South Chester Corp., Lester, Pa.

Southco Screws



Form: Three-piece, screw fastener: Screw, retaining washer, and stamped nut. Screw is inserted through panel, washer is attached, and screw is threaded into nut to lock.

Design Features: Floating action. Washer keeps screw captive.

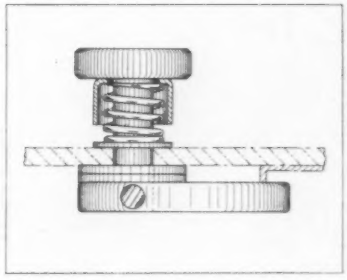
Materials: Screw, carbon steel; nut, carbon and corrosion-resistant steel; washers, nickel-silver.

Sizes: Screw diameter, 0.230 and 0.312 in. Screw length, 0.486 to 1.501 in.

Design Options: Screw head styles include knurled, wing, and slotted types. Nut styles include rivet or weld, saddle, U, and J spring-action types.

Source: Southco Div., South Chester Corp., Lester, Pa.

Southco Spring-Tension Latch



Form: Five-piece, quarter-turn, spring-loaded latch: Stud, washer, ferrule, spring, and pawl. Slight inward pressure on stud releases spring tension, and quarter turn of knob engages pawl.

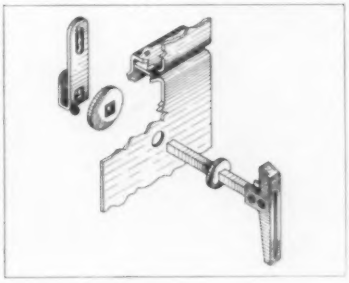
Design Features: Minimum of inside operating clearance. Adjustable to various thicknesses with washer spacers. Arrow on knob indicates position of pawl.

Materials: Knob and stud, zinc; ferrule, brass; spacers, aluminum; other parts, steel.

Sizes: Stud diameter, 0.257 in. Max panel thickness, 0.312 in.

Source: Southco Div., South Chester Corp., Lester, Pa.

Southco Universal Latch



Form: Four-piece, quarter-turn latch: Actuator, washer, push-on clip, and pawl. The washer is assembled on actuator stem, stem is inserted in pawl hole, push-on clip is put on stem, and pawl is attached by set screw. Quarter turn of actuator engages pawl.

Design Features: Adjustable grip.

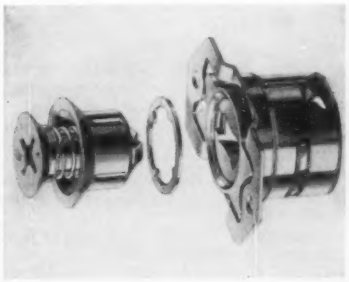
Materials: Steel.

Sizes: Actuator stem, 3/16-in. square. Max panel thickness, 1¾ in.

Design Options: Actuator styles include slotted-head, knob, and handle types.

Source: Southco Div., South Chester Corp., Lester, Pa.

SPF



Form: Two-piece, partial-turn fastener: Stud with pre-assembled bushing, and receptacle with threaded insert. As stud is rotated, stud lugs first engage insert and then insert moves down in receptacle, locking panels together.

Design Features: Continuous thread engagement is maintained by retained insert. Shear loads are carried by bushing. Stud too long or too short will not fasten. Vibration resistant. Floating receptacle accommodates tolerances.

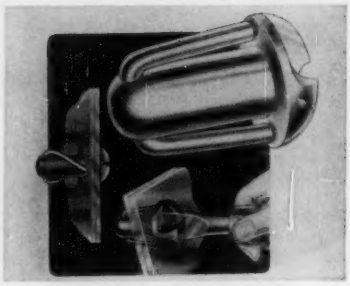
Materials: Steel.

Size: Stud diameter, ⅜ in. Rivet spacing, ⅞ and 1 in. Range of panel thickness, 0.58 to 0.657 in.

Design Options: Head styles include flush, plus flush, and wing types.

Source: Camloc Fastener Corp., Paramus, N. J.

Spring-Lock



Form: One-piece, quarter-turn fastener: Rivet-like pin with locking element made of spring steel wire. Wire is inserted through end of pin and bent back to form two flexible supports. Rotating fastener quarter turn in suitable punched panels causes the wire to flex into a spiral shape. A second quarter turn locks panels together. A third quarter turn in same direction releases assembly.

Design Features: Permanently retained. Blind application. Vibration resistant.

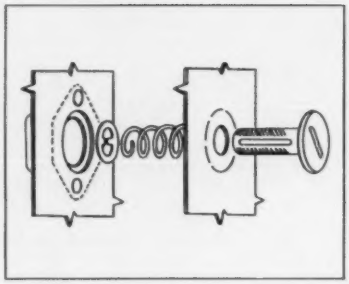
Materials: Locking wire, spring steel; body, steel and plastic, or plastic over metal insert.

Sizes: Stud diameter, 1/8, 5/32, 3/16, and 1/4 in. Range of panel thickness, 1/64 to 3/16 in.

Design Options: Head styles include oval and wing types. Clinch grommets.

Source: Simmons Fastener Corp., Albany, N. Y.

Turnlock



Form: Two-piece, quarter-turn fastener: Stud assembly with special interrupted thread, and receptacle. Stud is inserted through panel into receptacle. A quarter turn of stud engages threads, pulling stud into nut and locking assembly.

Design Features: Adjustable to various thicknesses. Adaptable to multiple-form strip fastening. Requires special tool.

Materials: Alloy steel.

Sizes: Stud diameter, 3/16 and 1/4 in. Stud length, 5/8, 7/8, and 1 in. Rivet spacing, 3/4 and 1 3/8 in.

Design Options: Head styles include flush and round types.

Source: Airtek Dynamics Inc., Los Angeles, Calif.

Ty-loc

Form: Two-piece, partial-turn fastener: Stud and locking assembly. Stud is inserted in locking assembly, and partial turn of actuating screw locks stud in place.

Design Features: Three-position actuating screw provides lock, open, and closed adjustments. Plug closes stud hole when stud is removed.

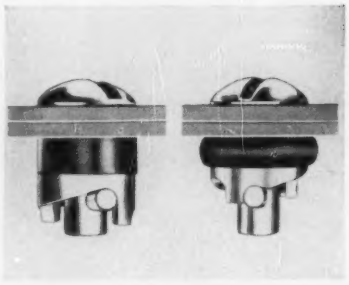
Materials: Aluminum and steel.

Sizes: Stud diameter, 0.545 in. Envelope, 7/16-in. by 3-in. diameter.

Design Options: Stud head styles include handle and flush types. Various locking assembly shapes. Light and heavy-duty designs.

Source: Davis Aircraft Products Inc., New York, N. Y.

Vibrex



Form: One-piece, half-turn fastener: Stud, rubber sleeve, nylon cam, and pin. Assembly is inserted in prepared hole. Frictional resistance of rubber sleeve against panel and nylon cam prevents rotation of cam. A half-turn of stud causes pin to ride up cam, compressing rubber sleeve. Compressive force developed locks panels together.

Design Features: Rubber-sleeve design minimizes panel preparation. Compensates for misalignment.

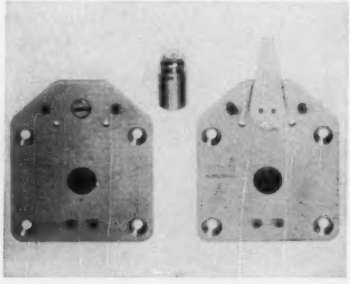
Materials: Stud, cadmium or nickel plated steel; sleeve, rubber; cam, nylon.

Sizes: Stud diameter, 5/16 and 1/2 in. Range of panel thickness, 1/32 to 5/8 in.

Design Options: Basic styles include flush, cushion, button, and shock mount types. Stud head styles include slotted, wing, ring, and special types.

Source: General Tire and Rubber Co., Industrial Products Div., Wabash, Ind.

Wedjit



Form: Two-piece, partial-turn fastener: Stud and snap release mechanism with holding device. Stud is locked in place when pushed into receptacle hole. A 40-deg turn of release mechanism unlocks stud.

Design Features: Vibration resistant fastener. Operation unaffected by dirt or foreign matter.

Materials: Plates, aluminum; jaws, mechanism, and studs, steel.

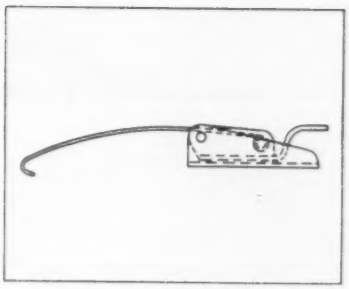
Sizes: Clearance required for operating mechanism 13/32 by 1 5/8 by 3 1/8 in. Stud diameter, 0.545 in.

Design Options: Flush or surface mounting styles. Actuating types include screw head, thumb-turn, or kick-turn. Various mounting plate shapes and stud types.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif. and Adams-Rite Mfg. Co., Glendale, Calif. Photo, courtesy Monadnock Mills.

LEVER-ACTUATED TYPES

Adams-Rite Over-Center Latch



Form: One-piece, tension-latch assembly used with strike or lip on panel. The strap is engaged in lip or striker and lever is depressed, pulling units together. Strap tension holds latch closed.
Design Features: Requires 10-lb latching force. Withstands load of 250 lb.
Materials: Steel.
Sizes: Envelope, 0.56 by 0.91 by 3.58 in., excluding strike.
Source: Adams-Rite Mfg. Co., Glendale, Calif.

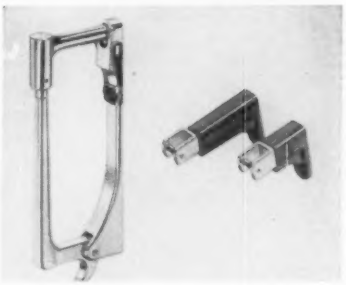
Bassick Spring Loaded Clamp

Form: One-piece, recessed, tension-latch assembly used with or without a strike: Recessed base plate, actuating lever, engagement strap, and two coil springs. Free end of the strap is hooked over lip or strike, lever is depressed, and cam action pulls components together. Tensile pull is exerted on engaging strap by coil springs.
Design Features: Recessed base provides flush mounting. Multiple 70-lb springs cushion operation of unit and provide constant tension. Linkage mechanism adjusts for mounting discrepancies.
Materials: Steel alloy.
Sizes: Envelope, 0.66 by 2.22 by 4.39 in. to 0.55 by 2.38 by 5.66 in., excluding strike.
Design Options: Modified designs include various base and strap configurations.
Source: Bassick Co., Div. of Stewart-Warner, Bridgeport, Conn.

Bassick Strap Spring Clamps

Form: Two-piece, tension-latch assembly: Strike and base unit. To operate latch, actuating lever is placed in up position, free end of strap spring is engaged in strike, and lever is depressed. Pressure applied to strap pulls mating parts together, and spring force in strap holds latch closed.
Design Features: 50 to 75-lb closing pressure.
Materials: Steel alloy.
Sizes: Surface dimensions, 1⅞ by 2 29/32 in. to 1⅞ by 3⅝ in. excluding strike.
Design Options: Modified designs include various strike and base configurations. Strap designs include hook, loop, or hinge types.
Source: Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn.

Camloc Electronic Chassis Latch



Form: Two-piece latch assembly: Fork attached to rack, and handle unit attached to chassis by handle plate. Removal of the unit is accomplished by depressing top of handles to release lock, pulling handle down to disengage chassis from rack, pulling chassis out, and returning handles to locked position. Installation is accomplished by opening handle, pushing chassis in until handles engage fork, and raising handles into locked position.
Design Features: Combines latch and handle in one assembly. Provides quick release and lock operation. Max horizontal load per latch is 600 lb ultimate.
Materials: Zinc alloy or aluminum.
Sizes: Required panel height, 4 or 5-in.
Design Options: Modified design includes safety catch, adjustable fork, and extended handle.
Source: Camloc Fastener Corp., Paramus, N. J.

Camloc Heavy Duty Latch

Form: Two-piece tension latch: Handle and shear-pin units. Closure is accomplished by engaging drawloop in shear-pin seat, pulling latch handle back, engaging shear-pin in handle unit, returning cover handle to closed position by releasing trigger, and locking assembly with quarter turn fastener.

Design Features: Shear pin corrects for angular approach of mating members. Overloading of panel automatically retracts shear pin. Pin and bushings withstand up to 10,300-lb tension and 8000-lb shear. Shear pin can be adjusted to compensate for wear.

Materials: Steel.

Sizes: Surface dimensions, 1⅛ by 4 9/16 in. to 2⅛ by 8 3/16 in. Max panel separation, ⅝ in.

Design Options: Modified designs for various load and environmental conditions.

Source: Camloc Fastener Corp., Paramus, N. J.

Camloc Push Button Latch

Form: One-piece, tension latch used against panel stop or strike. Operation of button pivots lever and rotates bolt head into cage to open. Bolt head is returned to strike by spring-action when button is released.

Design Features: Raised center of pushbutton permits flush mounting.

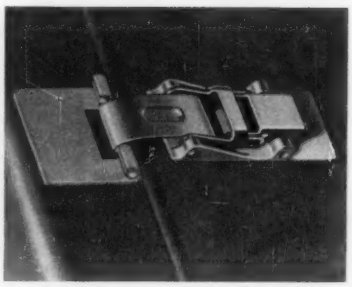
Materials: Carbon or stainless steels.

Sizes: Envelope, 11/16 by 1⅜ by 2 in. and 11/16 by 1 5/16 by 2 1/16 in.

Design Options: Modified designs include various cage and lever configurations.

Source: Camloc Fastener Corp., Paramus, N. J.

Camloc Toggle-Tension Latch



Form: One-piece, cam-action, spring latch assembly used with strike or lip. Drawhook is placed in strike, and lever unit is depressed to close and lock assembly. To open, release lever is raised, lifting primary lever by cam action. Entire lever unit is then raised to disengage drawhook.

Design Features: Ultimate strength of 150 lb. Shallow envelope permits face to face storage of equipment. Latch may be lockwired in closed position.

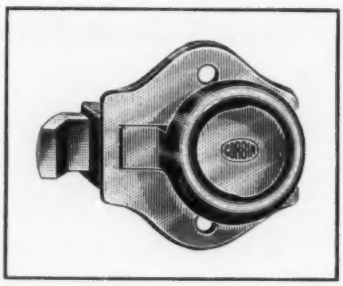
Materials: Base, aluminum; other parts, steel.

Sizes: Envelope, 3/16 by 21/32 by 1⅞ in., and 3/16 by 21/32 by 1 9/16 in.

Design Options: Drawhook styles include hook and pin types. Modified designs include various base and drawhook configurations.

Source: Camloc Fastener Corp., Paramus, N. J.

Corbin Panel Board Catch



Form: One-piece pull latch used with or without strike. Latch is opened by pulling ring which disengages latch bolt from panel or strike.

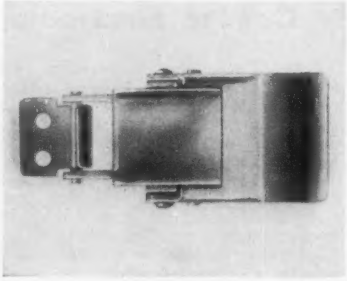
Design Features: Reversible. Panel requires special hole to provide for flush mounting.

Materials: Pull, brass; other parts, steel.

Sizes: Envelope, ⅞ by 1 11/16 by 2 5/32 in.

Source: Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

Draw Bolts



Form: One-piece, spring-latch assembly used with strike. Free end of bolt loop is hooked over strike. Lever is depressed and bolt loop pulls slightly out of housing, compressing springs, to lock.

Design Features: Provides locking force from 42 to 100 lb. Accidental release is prevented by spring action.

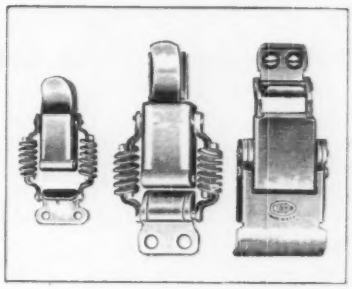
Materials: Steel and stainless steel.

Sizes: Typical surface dimensions, ⅜ by 1¼ in. to 1⅛ by 3 in. depending upon manufacturer.

Design Options: Modified designs include various strike and base configurations.

Source: Produced by several manufacturers. Illustration, courtesy of Excelsior Co., Stamford, Conn.

Draw-Pull Catches



Form: One-piece, tension latch used with strikes. Free end of loop is hooked over strike, and parts are pulled together when the lever is depressed. Unit is locked under tensile force of wire or by springs.

Design Features: Develops spring tension from 20 to 100 lb. Assembly adjusts to proper holding position.

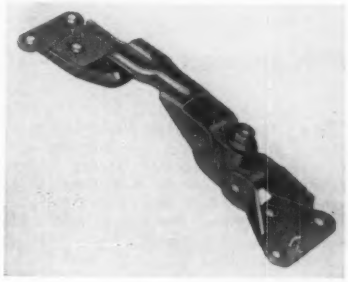
Materials: Steel and brass.

Sizes: Typical envelope, 5/8 by 7/8 by 1 5/16 in. to 1 by 1¾ by 3¾ in., depending upon manufacturer.

Design Options: Modified designs include concealed-spring type, and various strike and base configurations.

Source: Produced by several manufacturers. Illustrations courtesy of Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

Gear-Lock



Form: One-piece, worm-gear clamp used with or without strike. Rotation of the locking nut turns worm gear and drops engaging link into strike or panel. Further rotation clamps link in place.

Design Features: Withstands heavy shock, vibration, and loads. Closing pull of 2000 lb. Locking nut requires standard wrench for tightening.

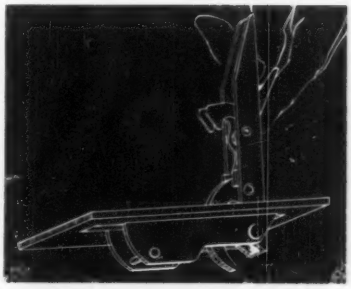
Materials: Steel alloy.

Sizes: Length, 3⅞ to 8⅜ in.

Design Options: Modified designs include external, external recessed, and internal types.

Source: Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn.

Hartwell Hook Latch



Form: One-piece, toggle-action, hook latch. Opening of release trigger permits body of latch to rotate about pivot pin, which permits hook to swing clear of engaging pin.

Design Features: Two-pin action insures against accidental opening. Cam provides force for closing.

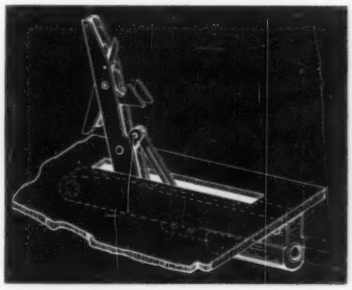
Materials: Steel and aluminum alloy.

Sizes: Cutout dimensions, 1 by 4 5/32 in. and 1⅛ by 6 9/16 in.

Design Options: Modified designs include single, double, adjustable, and cowl-hook types.

Source: Hartwell Co., Los Angeles, Calif.

Hartwell Pin Latch



Form: One-piece, sliding-bolt latch. Latch is opened when release panel is depressed to disengage hook. Operating lever is then lifted, retracting pin type bolt. Closure is accomplished by depressing lever back to flush position, reengaging bolt and release-panel hook.

Design Features: Double-locking action prevents accidental opening. Pin engagement permits latch to be used as pivot. Bolt stop limits bolt retraction. Tapered pin assures complete closing.

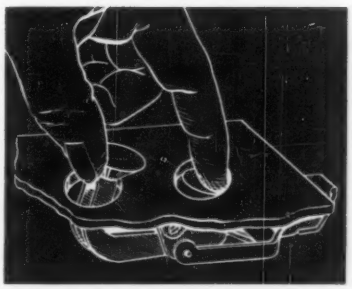
Materials: Steel and aluminum.

Sizes: Cutout dimensions, 9/16 by 4½ in. to 1 5/32 by 5 9/16 in.

Design Options: Modified designs include various mounting, handle, and pin configurations.

Source: Hartwell Co., Los Angeles, Calif.

Hartwell Self-Closing Latch



Form: One-piece, bolt latch. Release panel retracts bolt through mechanical linkage when depressed. Bolt is returned through spring action.

Design Features: Bolt is automatically reset when door or panel is closed. Positive closure when door is slammed.

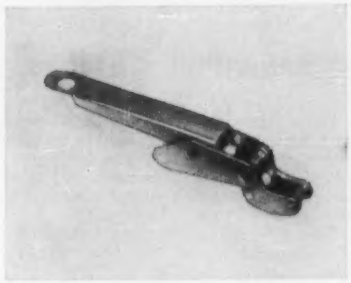
Materials: Steel and aluminum.

Sizes: Envelope, 0.52 by 1½ by 2 13/32 in. and 0.59 by 1½ by 3 11/32 in.

Design Options: Modified designs include various base-unit and handle configurations.

Source: Hartwell Co., Los Angeles, Calif.

Hartwell Toggle Bolt Latch



Form: One-piece, toggle latch. Lever handle is depressed and catch unit swings up to engage hook or flat bearing surface. Lever handle is lifted to disengage hook. Latch is secured in closed position by flush stud fastener through lever handle.

Design Features: Swing-up action provides vertical force to compress panel in place.

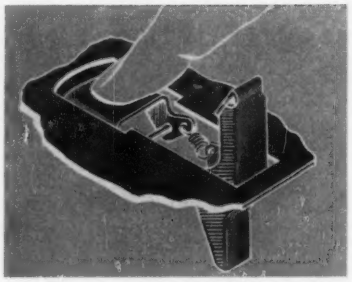
Materials: Steel and stainless steel.

Sizes: Cutout dimensions, 15/16 by 5 3/16 in.

Design Options: Modified designs include various body, handle, link, and hook styles.

Source: Hartwell Co., Los Angeles, Calif.

Hartwell Trigger-Action Latch



Form: One-piece, bolt latch. Latch is opened by depressing a trigger to release bolt which swings 90 deg under spring action. Closure is accomplished by moving the bolt back into position.

Design Features: For use in thin and medium-thickness panels.

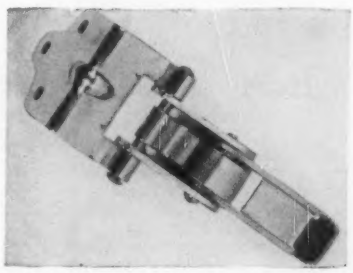
Materials: Steel, aluminum, and stainless steel.

Sizes: Cutout, 1 1/16 by 1 9/32 in. to 2¼ by 3 19/32 in.

Design Options: Modified designs include various mounting, body, bolt, and release configurations.

Source: Hartwell Co., Los Angeles, Calif.

Hinge Clamp



Form: Two-piece, tension latch: Strike and base unit. Strike bar is inserted in pronged end of base unit and strap hook is placed over strike bar. When lever is depressed, components are pulled together and locked.

Design Features: Pronged base and hook on strap permit the fastener to be used as hinge when in closed position. Spring strap is protected against accidental tripping by high base sides.

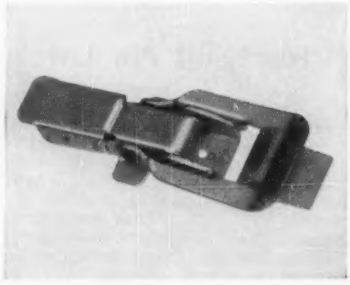
Materials: Steel alloy.

Sizes: Surface dimension, 15/16 by 3 9/32 in.

Design Options: Modified designs include various strike and base configurations.

Source: J. H. Sessions and Son, Bristol, Conn. and Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn. Illustration, courtesy of J. H. Sessions and Son.

Nielsen Catch



Form: One-piece, loop latch used with striker. Depression of release plate permits latch to open. Loop is then withdrawn from striker.

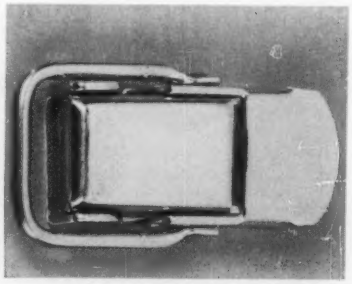
Design Features: Protected against accidental release. Withstands loads to 3000 lb.

Materials: Aluminum.

Sizes: Envelope, ¾ by 2¼ by 4 27/64 in. excluding striker.

Source: Nielsen Hardware Corp., Hartford, Conn.

Sessions Spring Catch



Form: Two-piece, spring latch: Base unit and striker. Engagement loop is hooked over striker and lever is depressed, closing unit against force of springs. To open, the finger tab is lifted, moving main housing away from base. Lever unit is raised to unhook loop.

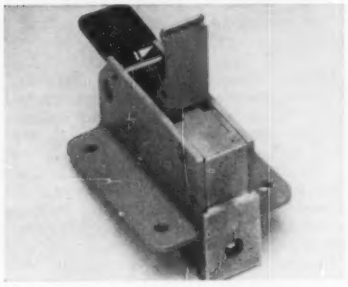
Design Features: Accidental release prevented by spring action. Engagement loop has 70-lb preload which increases to 100 lb when loop is deflected ⅛ in.

Materials: Steel.

Sizes: Envelope, ¾ by 1¾ by 4 in.

Source: J. H. Sessions and Son, Bristol, Conn.

Simmonds Bolt Latch



Form: One-piece, bolt latch. Depression of spring-loaded actuating tab releases bolt lever, retracting bolt. Closure is accomplished by depressing bolt lever, which locks under release tab.

Design Features: Develops shear strength of 4500 lb. Large bolt travel for small lever movement.

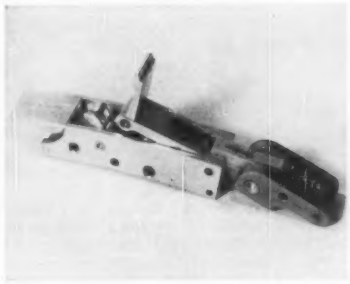
Materials: Body, aluminum; pinion and bolt, steel.

Sizes: Envelope, 1 7/8 by 2 1/16 by 4 1/8 in.

Design Options: Modified designs include flush or flange mounting types.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.

Simmonds Cam Lever Latch



Form: Two-piece, toggle latch: Toggle member and receptacle. Latch is opened by pressing spring-loaded release lever on receptable to unlock toggle member. A spring kicks hinged toggle up to provide a lever for raising toggle unit.

Design Features: Toggle working length is adjustable. Self-closing.

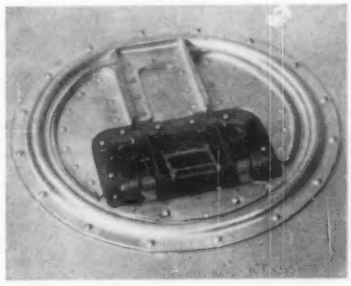
Materials: Aluminum and steel alloys.

Sizes: Envelope, 1 by 1 1/8 by 4 7/8 in. to 1 3/4 by 2 by 7 1/2 in.

Design Options: Modified designs include flush types for general-purpose and high-strength applications.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.

Simmonds Panel Latch



Form: One-piece, latch assembly. Depression of treadle releases latching mechanism. Panel is then removed as hand is withdrawn.

Design Features: Serves as a handle as well as a latch. Large push area facilitates opening. Catch area is balanced against air pressure. Latch remains captive in panel which is removed.

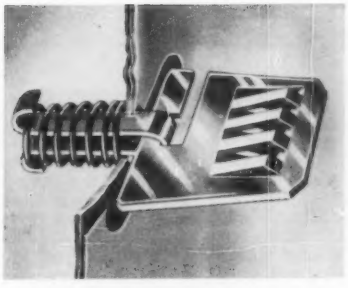
Materials: Aluminum.

Sizes: Envelope, 3/4 by 3 1/8 by 4 7/8 in.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.

SLIDE-ACTION TYPES

Lite-Lok



Form: Three-piece, sheet-metal slide fastener: Tab, yoke, and spring. Unit is installed by slipping the spring over yoke, inserting yoke through hole in frame, and sliding tab into yoke where it is retained by a notched seat. Tab is passed through slot in panel, turned 90 deg, and flipped flat against the sheet.

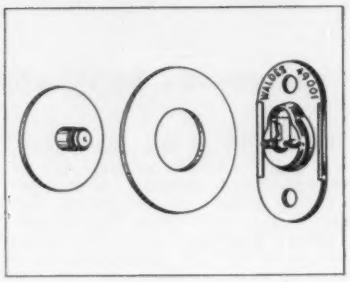
Design Features: Eliminates thumbscrews. Requires no special assembly tools.

Materials: Spring steel.

Sizes: Range of panel thickness, up to 5/32 in.

Source: Southco, Div. of South Chester Corp., Lester, Pa.

PLF



Form: Three-piece, snap fastener: Stud subassembly, washer, and receptacle. When stud and housing subassemblies are engaged, a retaining ring locks stud to housing. Stud is released by pushing it down into receptacle and then toward open end. When stud is pressed deeper into receptacle, locking spring is compressed and stud is shifted out of retaining ring.

Design Features: Locks against any combination of forces. Stud subassembly floats ¼ in. in any direction.

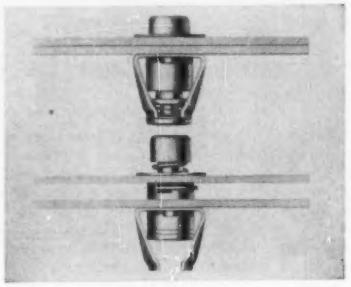
Materials: Stud, stainless steel; washer, aluminum; receptacle, steel.

Sizes: Envelope, 0.370 by 1 by 1⅞ in. Washer diameter, 1¾ in. Stud diameter, 1 3/16 in.

Design Options: Modified designs include horizontal and vertical types.

Source: Waldes Kohinoor Inc., Long Island City, N. Y.

Pres-Loc



Form: Three-piece, slide fastener: Receptacle, retaining ring, and preassembled stud unit. Stud is inserted through panel to engage receptacle and stud button is then pressed to lock assembly. To unlock, button is pressed to force spreader between receptacle leaf springs, permitting unit removal.

Design Features: Requires no special tools for installation. Retaining ring holds stud assembly captive.

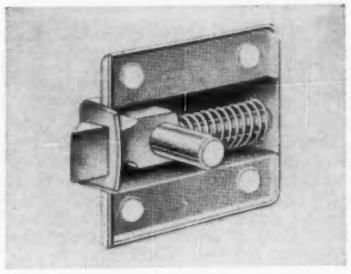
Materials: Steel.

Sizes: Stud diameter, 0.386, 0.453, and 0.515 in. Range of panel thickness, 0.62 to 1.87 in.

Design Options: Stud styles include protruding, flush, and flange button types.

Source: Deutsch Fastener Corp., Los Angeles, Calif.

Slidebolts



Form: One-piece, bolt latch used with striker plate. Sliding knob actuates bolt against spring-loaded arm which keeps bolt extended when knob is released.

Design Features: Automatic return of bolt permits panel to be securely closed when slammed.

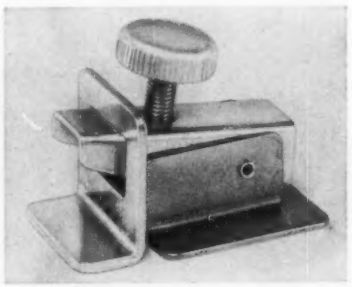
Materials: Steel, brass, and aluminum.

Sizes: Typical envelope, up to 1 by 2½ by 3 in. depending upon manufacturer.

Design Options: Modified designs include various housing, bolt, and actuating knobs.

Source: Produced by several manufacturers. Illustration, courtesy of Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

Slide Latch



Form: Two-piece, slide latch: Pawl unit and striker. Pawl slides into striker and is tightened against striker surface by turning screw knob.

Design Features: Seals door and frame, or panel, units under pressure. Latch does not require precision alignment and tolerates variations in elements.

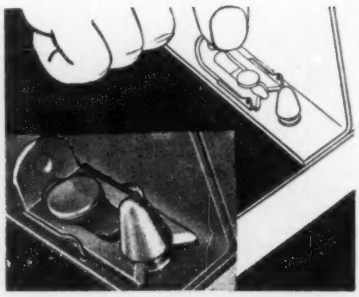
Materials: Steel.

Sizes: Envelope, 1 by 1¾ by 2 3/32 in., and 1½ by 1½ by 2 3/16 in.

Design Options: Modified designs include various housing, and mounting configurations.

Source: Southco, Div. of South Chester Corp., Lester, Pa. and Torit Mfg. Co., St. Paul, Minn. Illustration, courtesy of Torit Mfg.

Snapslide



Form: Five piece, slide fastener: Stud, guide, slide, spring washer, and button. Stud is fastened to fixed portion of panel, and guide, slide, and washer are fastened to removable panel by button rivet. To lock assembly, removable panel and guide are assembled on stud, and slide is moved forward so that pronged end of slide engages narrow section of stud.

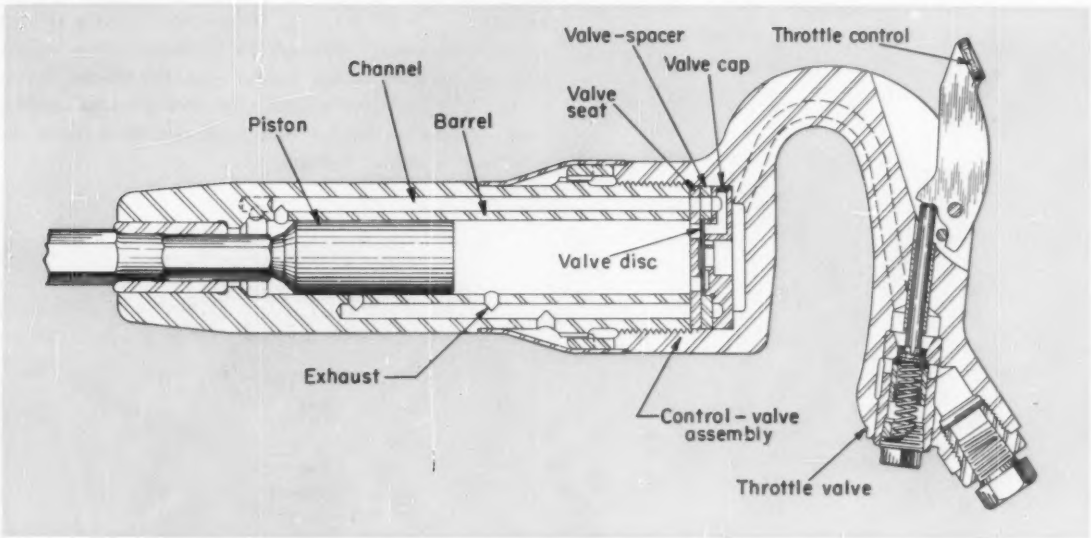
Design Features: Requires no tools for operation. Requires no adjustment. Shockproof and vibration resistant.

Materials: Brass and steel.

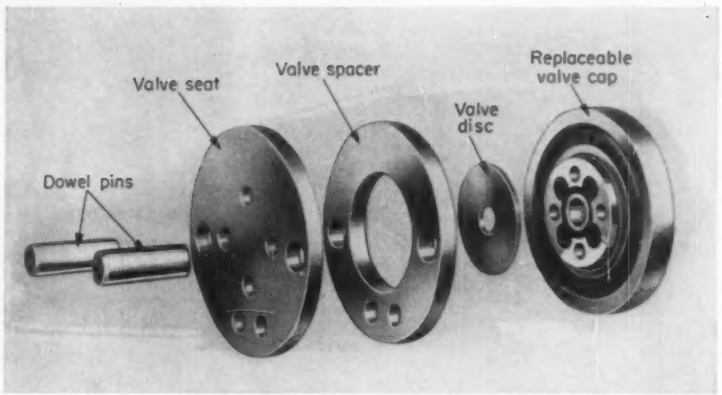
Sizes: Surface dimensions, 7/32 by 19/32 in. to 9/16 by 1 15/32 in.

Source: Dimco-Gray Co., Dayton, Ohio and Aircraft Radio Corp., Boonton, N. J. Illustrations courtesy of Dimco-Gray Co.

Interchangeable Valve-Cap Designs Control Air-Hammer Power

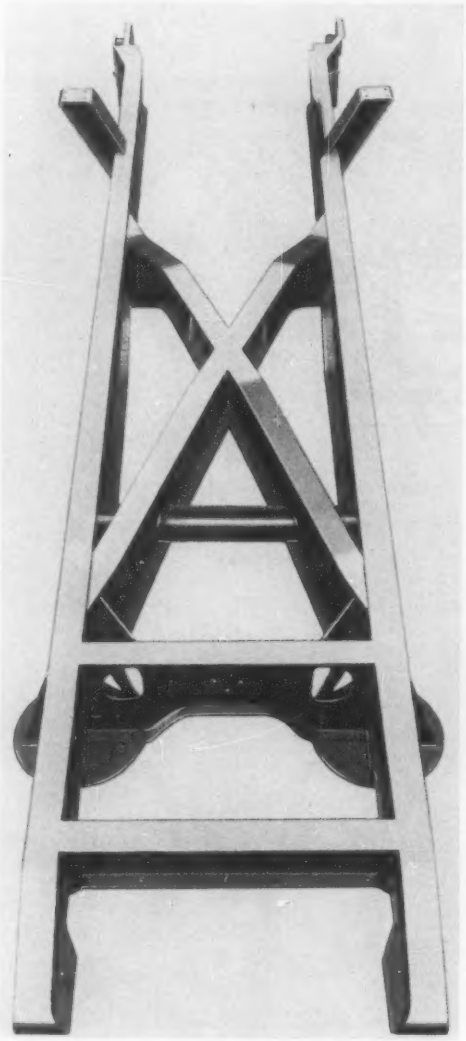


POWER-RATING CHANGES in a new Ingersoll-Rand chipping hammer are accomplished by simply changing one part in the air control valve. The chipping hammer is designed to take either a normal cut, extra cut, or super cut, depending on which one of three valve-cap designs is used in the control valve. In operation, the valve disc alternately seats itself against the valve seat and valve cap. Valve-disc travel distance and, in turn, hammer power are governed by how far the protruding face of the valve cap enters the spacer.

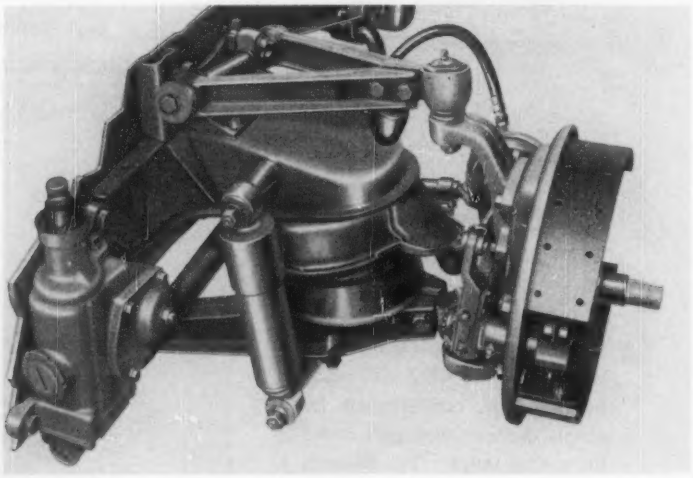


SEQUENCE OF OPERATION starts when the throttle is pressed, allowing air under pressure to enter the control valve. The hole in the center of the valve disc meters the air to the back of the piston, driving it ahead. As the piston travels forward, it exposes the air exhaust port at the bottom of the barrel, and air rushes out. This action slams the valve disc shut against the valve seat, and diverts air through a channel to the port above the location where the piston strikes the cutting tool. This air pressure against the tapered head of the piston forces it back. When the piston returns, it opens the control valve and the cycle repeats.

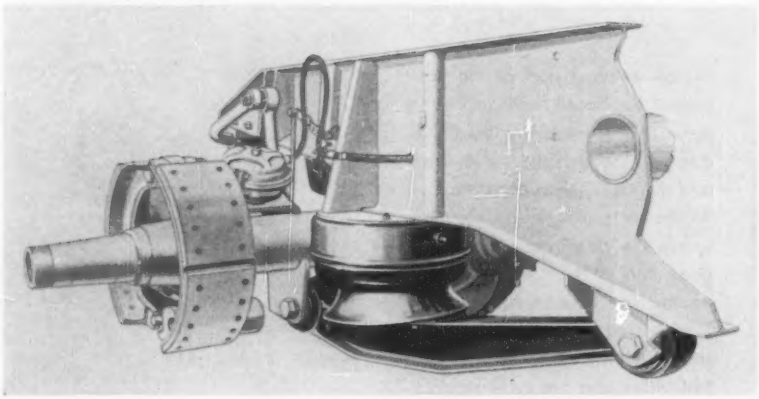
High-Tensile Welded Steel Frame



FABRICATED I-BEAM FRAME used in the new General Motors DLR-8000 highway tractor weighs 300 lb less than a conventional pressed-steel channel design. Each I-beam member consists of 3/16-in. top flanges continuously welded to thin steel webs. Although the fabricated frame weighs only half as much as the channel type, the welded design of SAE 950 high-tensile steel adds strength and rigidity. Even with trailers loaded with fluid, additional frame reinforcements are unnecessary.



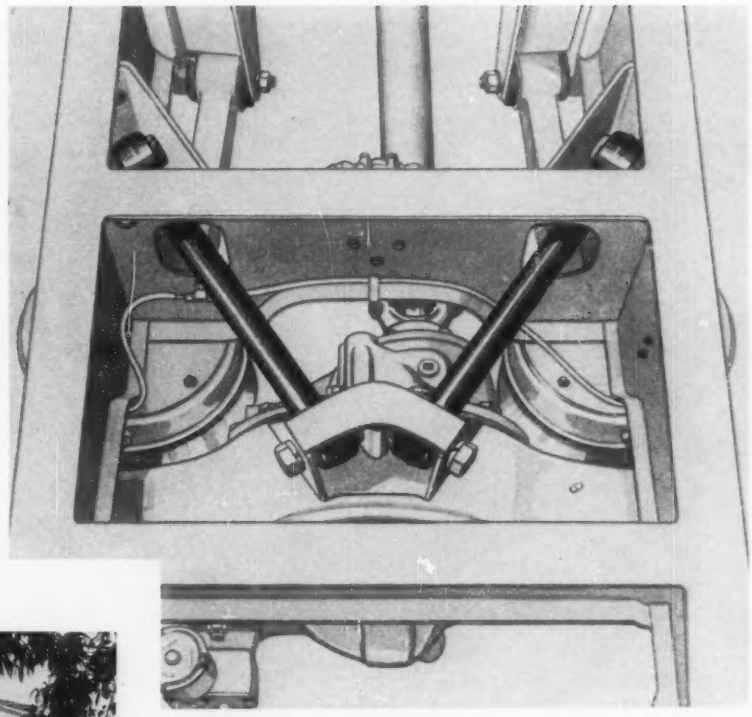
INDEPENDENT FRONT AIR SUSPENSION, designed integrally into the new frame, saves weight by eliminating the front axle. The suspension consists of a fabricated steel drop-center crossmember, bolted to the frame. The assembly uses a bellows air spring stabilized by bars connecting the upper suspension arm to the frame.



REAR AIR-SUSPENSION system employs two circular bellows, one on each side, with independent leveling valves. Each air spring fits between the frame and a lower radius arm, used for axle control.

Makes Highway Tractor Lighter

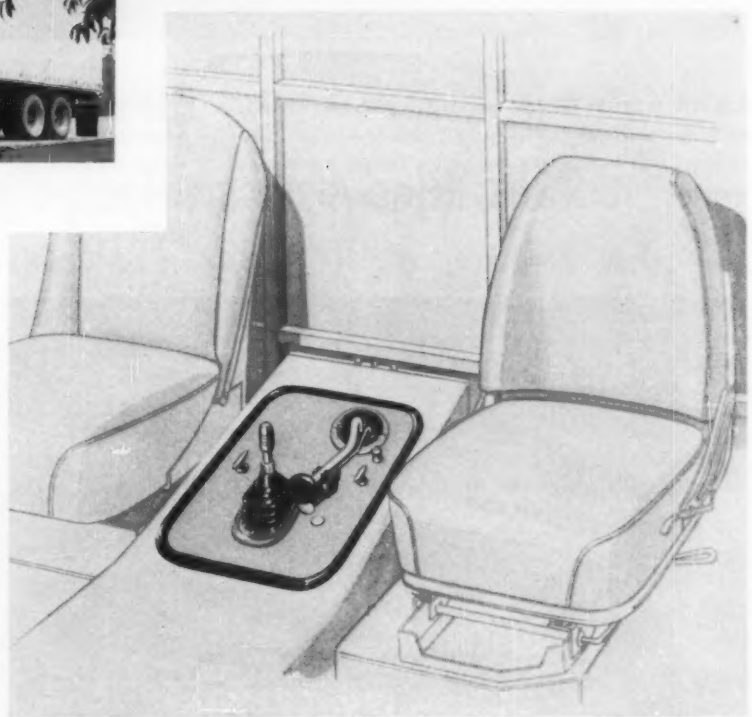
LATERAL SWAY is prevented by a pair of upper radius rods over the rear axle of the highway tractor.



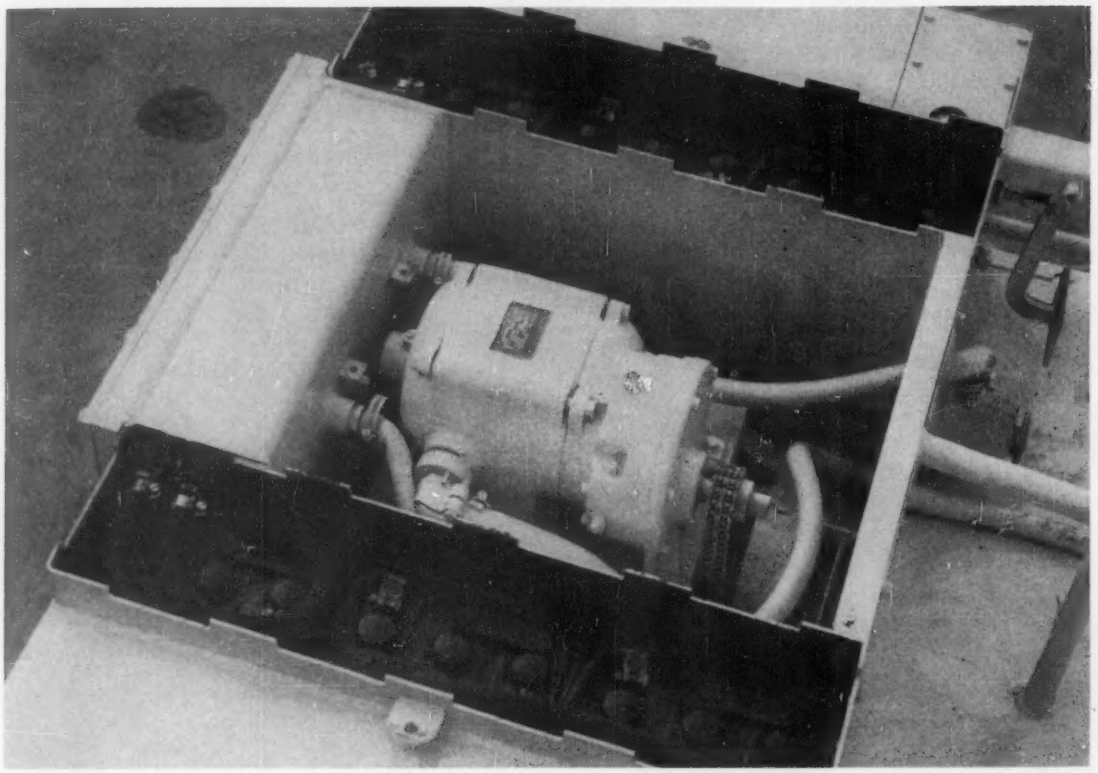
ALUMINUM TILT CAB on the DLR-8000 tractor is only 48 in. long from bumper to back of cab and weighs 700 lb less than previous designs. The air-suspension system absorbs the high-frequency road vibrations making an aluminum cab practical.

Further weight savings are obtained through the use of fiber-glass fenders.

CONTROL-ISLAND DESIGN brings tractor controls within easy reach of the driver. When the cab is tilted for maintenance work, the island stays in its fixed position, eliminating long flexible control cables and rods.

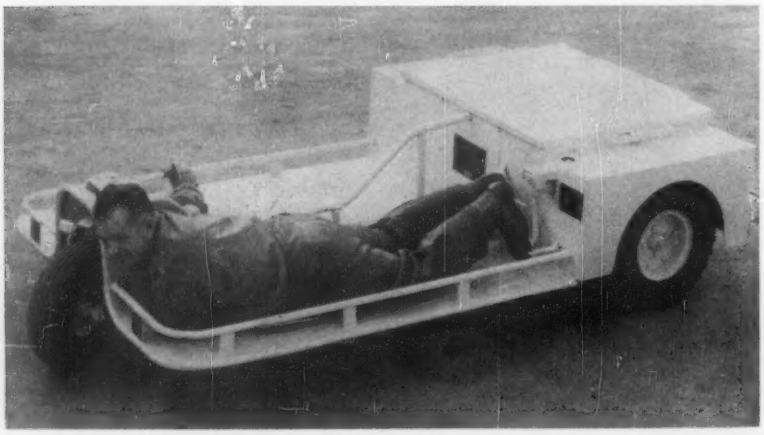


Mine-Vehicle Height Cut to 25 in.



ELECTRIC-MOTOR DRIVEN personnel-utility car is specially designed for use in tunnels and low-height areas in mines. Known as the Inspector's Friend, the battery-operated wagon can carry a 500-lb load at 4 mph.

The drive is a 1 ½ hp, 30-v Reliance gearmotor made by Master Electric Co. Div. Enough storage batteries are built into the car to drive it through two complete work shifts.



FOOT CONTROLS are designed so the operator can start and brake the vehicle whether he is in a prone or a sitting position. A switch in front has three positions—off, forward, and reverse.

The tiller steering mechanism makes it possible to turn the car in little more than its length.

The vehicle is manufactured by the Long Co., Oak Hill, W. Va.

Butterfly Valves
for high-performance applications

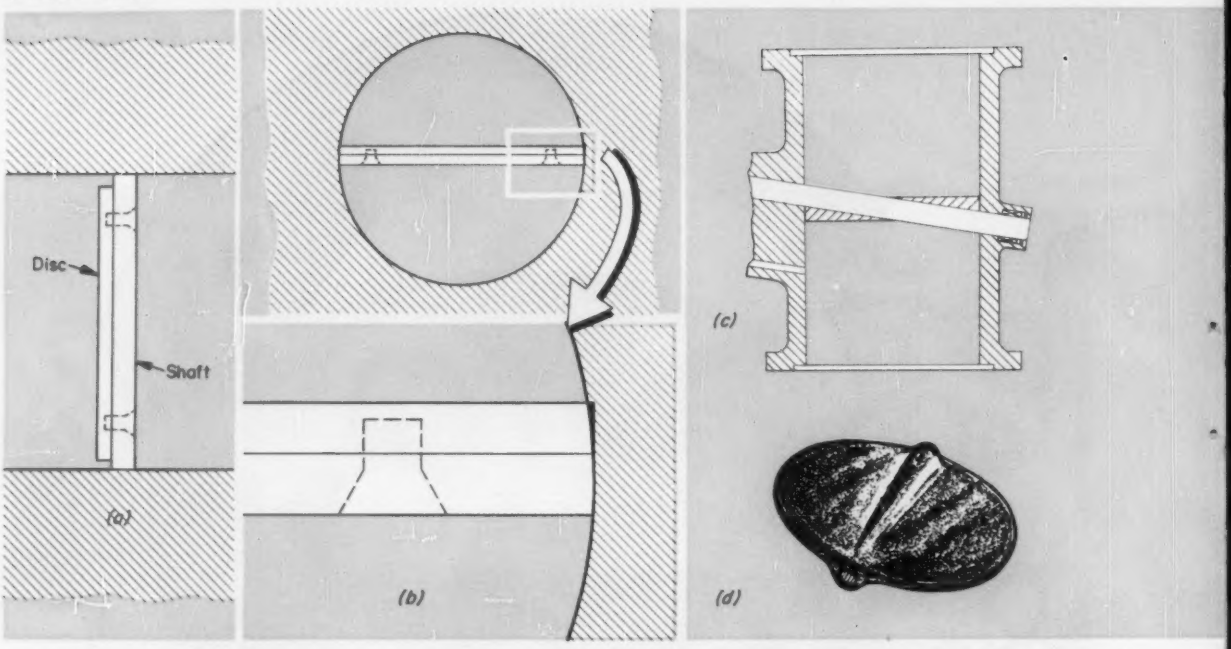
By **BOYD DAHLE,** Project Engineer, Parker Aircraft Co., Los Angeles, Calif.

Inherent advantages have made butterfly valves ideal for modulating air flow in pneumatic systems, within limits. This article presents a close look at recent advances in design which have extended the operational limits of these valves.

HIGH-PERFORMANCE butterfly valves for aircraft pneumatic systems are now being produced to handle flows greater than 500 pounds per minute with upstream pressures of 100 psi. At the same time, these valves permit a leakage when fully closed of 0.05 pounds per minute or less and handle velocities of 1000 feet per second or more when fully opened.

Leakage, actuation, and pressure losses are the three major characteristics considered in the application of butterfly valves. Since each of these factors depends upon the others, it is necessary to investigate several basic valve designs and how they affect these characteristics.

Types of Design: Each valve of the butterfly



leakage determines design

Fig. 1—Leakage determines shaft-disc arrangement. In applications where sealing is noncritical, through shafts with bolted discs *(a, b)* can be used. For the more critical sealing requirements, a canted shaft and clam shell design *(c, d)* is effective

type consists essentially of the same components. Although design varies to suit the particular application, the disc, shaft, and bore are integral parts of each valve.

Sealing requirements dictate, to a great extent, shaft orientation, and in turn, the shape of the disc. Where complete sealing is not required, the disc is made somewhat smaller than the bore of the valve, Fig. 1*a*. If the torque is low, the disc is simply bolted onto the shaft. Thus, the center of the disc is displaced from the center of rotation by the radius of the shaft and by half the thickness of the disc.

If only a small amount of leakage is allowed, the disc could be made to fill the bore, Fig. 1*b*. However, this is not possible, since the valve cannot be opened because the disc is displaced from the center of rotation. In addition, leakage through the screws, which attach the disc to the shaft, would be more than that usually allowed.

Other valve designs have been made with the shaft through the center of the disc and sealing rings around the periphery of the disc. However, none of these designs were feasible for low leakage applications.

An effective seal between disc and bore has been obtained by canting the shaft relative to the disc, Fig. 1c. In this valve, the disc fills the bore in the fully closed position, thereby minimizing the leakage. The specific design of the canted shaft allows the disc to pivot to the full open position. The modulating part of the valve now resembles a clam shell, and is called such.

A tube is molded into the clam shell to provide sufficient metal to attach it to the shaft, and the shell is tapered towards the outside edge, Fig. 1*d*, to reduce the weight. Since the ratio of shaft thickness to bore diameter directly influences the pressure drop in the full open position, shaft and tube are designed to give the smallest possible shadow in this position.

Characteristics of Clam-Shell Valve: Since this basic design typifies that used in critical applications, the discussions on leakage, actuation and pressure losses for the clam shell design also apply to the application of butterfly valves in general.

LEAKAGE: Theoretically, a rigid clam shell seals itself perfectly in a rigid duct. However, since manufacturing and fabricating tolerances are such that a perfect fit is never accomplished, a flexible sealing device is required.

One seal often used is a flexible metal one on the inside of the valve bore. This seal is mounted either on the bore or on the clam shell. As the clam shell is closed, the flexible material deflects and a metal to metal seal between the bore and the clam shell is accomplished.

In some designs, an O-ring seal is used. However, since O-rings have a tendency to extrude under pressure and do not expand to original dimensions after loading, it is not desirable to rely entirely on an O-ring seal. The most satisfactory sealing arrangement is a combination of the O-ring and metal seals, Fig 2.

ACTUATION: To change the position of a clam shell in a butterfly valve, three different forces must

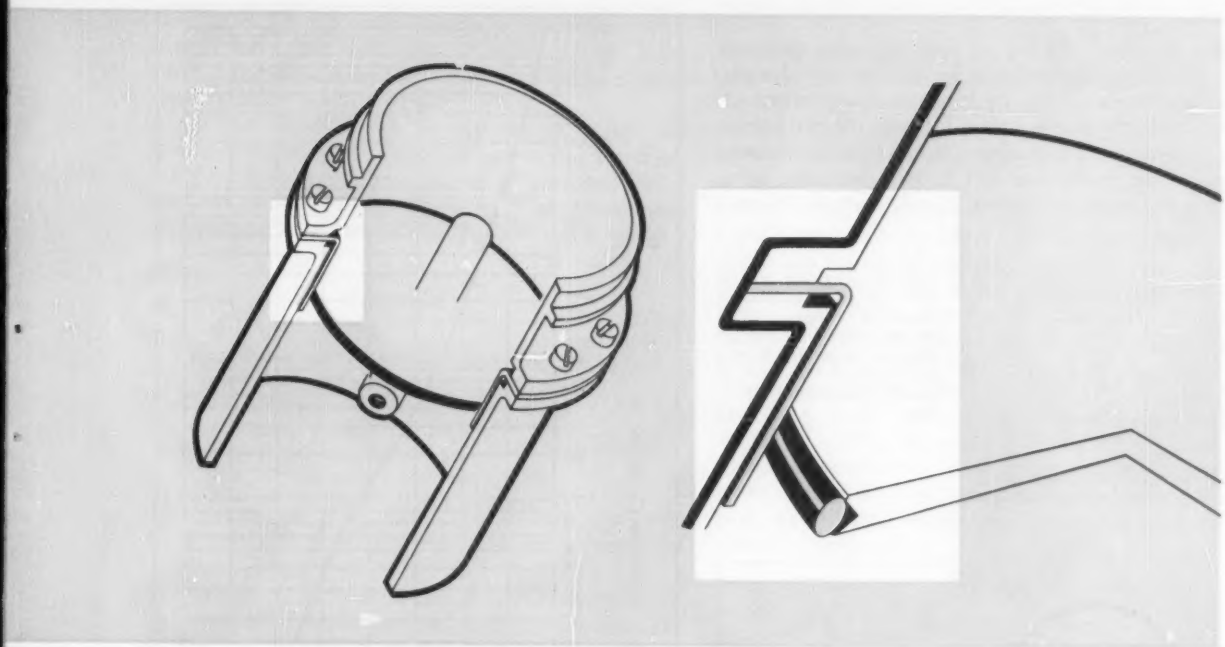


Fig. 2—Metal and O-ring combination seal. This combination allows for fabricating tolerances without an increase in leakage

be overcome; force due to friction in the bearings supporting the shaft, force due to the change in momentum of the fluid as it flows across the clam shell, and force due to the static pressure gradient across both sides of the clam shell.

The friction force in the bearings is dependent on the other two factors, since a force normal to the surface of the shaft is exerted on the bearings as the fluid forces push against the shell. Therefore, as the forces pushing against the butterfly increase, the friction also increases.

In order to examine the other forces more closely, it is necessary to take a look at the streamlines, Fig. 3, passing the clam shell. As the fluid flows past the shell, it accelerates across its face. The amount of acceleration depends on the degree of opening. Since the velocity reaches its maximum at the top, acceleration produces a static pressure gradient across the front of the shell. Also, there is a pressure gradient across the back of the shell caused by turbulence induced by the flow separation at the edges. Only the over-all characteristic of the resultant force is of interest in valve application.

In general, butterfly valves have a torque curve similar to that shown in Fig. 4. The peaks of the curve are important from the standpoint of valve actuation, and tests indicate that the forces vary directly with fluid density, the square of the flow velocity, and the cube of the valve bore diameter.

Although the shaft diameter influences the shape of the clam shell, the torque variations are almost independent of the configurations, with a minimum value at about 10 deg of opening and a maximum

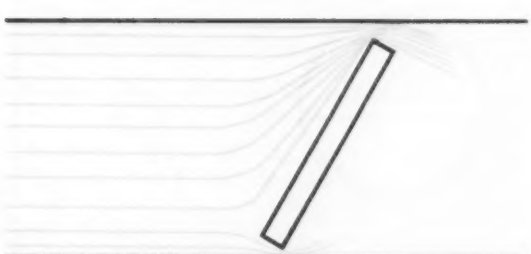


Fig. 3—Path of flow around disc. Streamlines indicate that most of the air flow accelerates across the front of the disc. This acceleration causes a pressure gradient across the front of disc and exerts a torque on the shaft

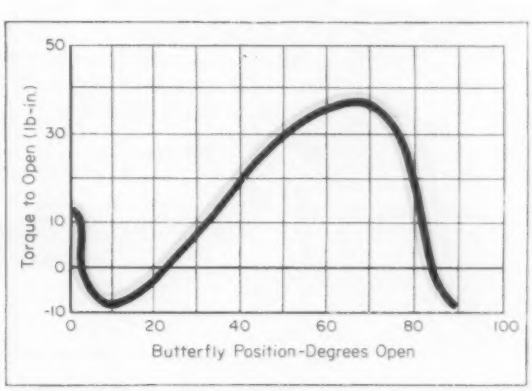


Fig. 4—Typical torque curve for butterfly valves. Values at curve peaks are important in determining the means of actuation

value at about 70 deg of opening. For purposes of estimating performance in preliminary designs, the magnitude of the peak points is approximated, and a straight line is drawn between the two points.

A finite amount of torque is required to overcome the friction in the seal and initially open the valve. Once the valve is cracked, it will open on its own accord to about 22 deg. Beyond this point, a torque must be applied to open the valve further.

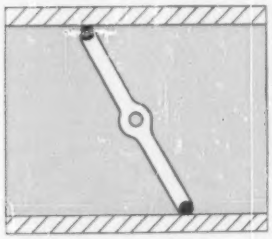


Fig. 5—Angular set of disc in bore eliminates negative torque. Flow control with this arrangement is generally better, but control accuracy at nearly closed position is less

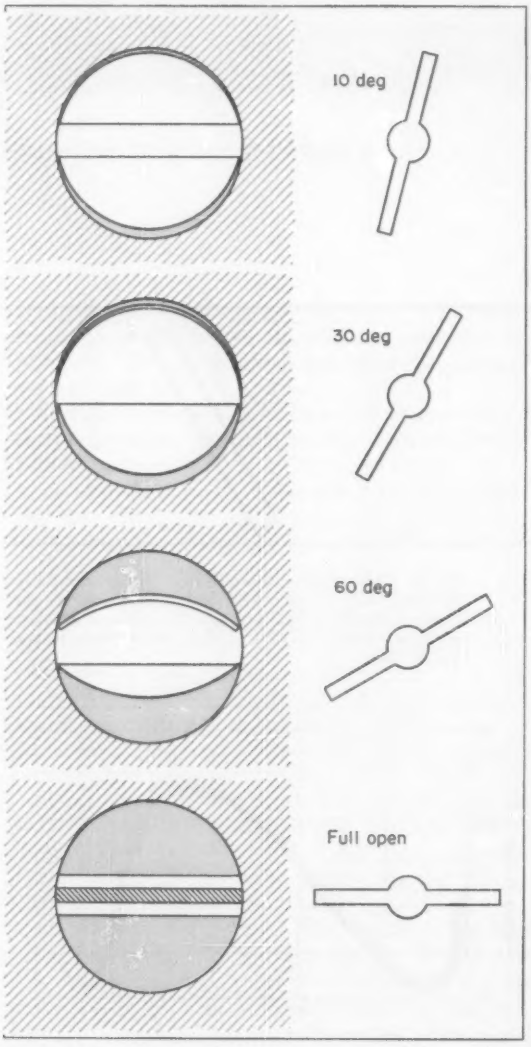


Fig. 6—Pressure losses vary with shaft and disc shadow. As valve opens, the shadow of the clam shell decreases and the shadow of the shaft becomes large compared to the shell thickness

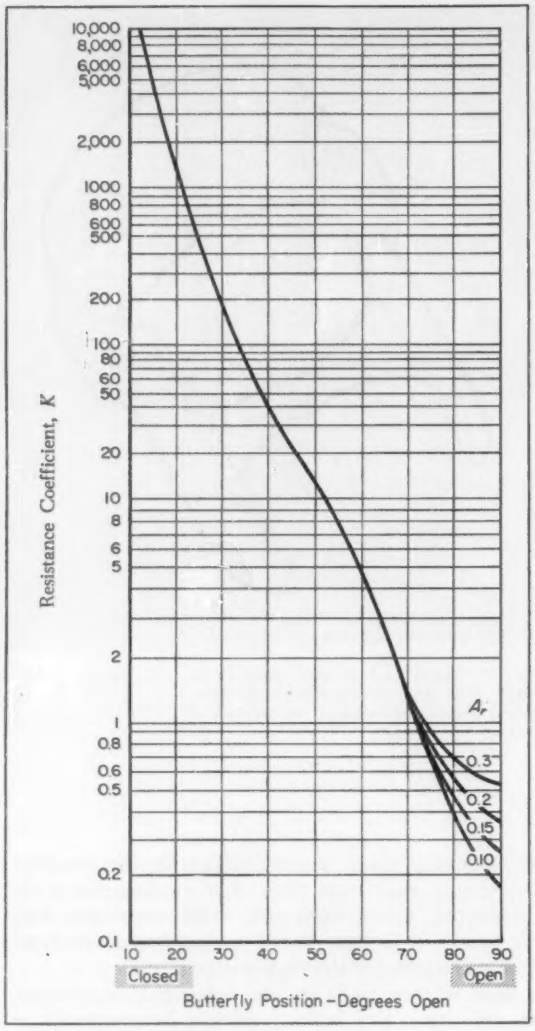


Fig. 7—Resistance coefficient as a function of valve opening. From K value and valve geometry, the pressure losses are determined

If it is necessary to provide flow modulation in the region where the valve has negative torque, then a positive linkage, such as an electrical motor and gears, is used to control the valve. Part of the time the valve will be helping to drive the motor. Therefore, it is necessary to provide a holding mechanism to keep the valve in a fixed position when the electrical power is off.

Negative torque has been eliminated in some designs by having the butterfly disc seal the duct at an angular position with respect to the centerline of flow passage, Fig. 5. In this canted shaft design, the shaft is perpendicular to the centerline of flow instead of canted. The exact angular position depends on the shape of the clam shell, but usually approximates 30 deg.

Since the total stroke is now only 60 deg, an incremental change in the angular position of the

shell produces a greater change in flow than with a total movement of 90 deg. With this design, flow control is generally better, but control at the nearly closed position is less accurate.

Another disadvantage to this canted design is the sealing problem. Since leakage through a butterfly valve is proportional to the pressure and sealing area, an increase in the angle of cant increases the leakage area due to the increase in perimeter, and causes an increase in leakage. For example, if the clam shell is designed so that it will close at an angle of 30 deg, then the perimeter is approximately 2.2 times the perimeter of a circular clam shell that seals the duct in a vertical position.

Nomenclature

A = Flow area, ft²
A_r = Area ratio, butterfly thickness/valve bore
g = Acceleration of gravity, 32.2 ft/sec²
K = Resistance coefficient
P = Static pressure, psf
P = Static pressure drop, psf
R = Gas constant, ft-lb/lb-deg Rankine
T = Static temperature, deg Rankine
W = Gas flow, lb/sec

PRESSURE LOSSES: One of the most important criteria for valve selection is the pressure loss through the valve. The pressure loss represents energy that is lost and cannot be used for useful work, and therefore, must be made up by the pumping system.

The shaft diameter and the valve bore determine the pressure loss when the valve is new or at the fully opened position. Tests indicate that the ratio of the maximum section thickness to bore diameter is an important parameter for determining these losses. This ratio has an important effect on the losses from the full open to 70 deg open positions, while the degree of opening determines the losses from closed to 70 deg open. It is shown in Fig. 6 that as the valve opens, the shadow of the clam shell decreases and the shadow of the shaft becomes large compared to the thickness of the shell.

In a typical graph, Fig. 7, resistance coefficient K for a clam shell is given as a function of the degree of opening. With the appropriate K factor, it is possible to determine the pressure losses from the properties of the air flowing through the valve. The basic equation in which the K factor is used (see Nomenclature), is

$$\Delta P = \frac{K R T W^2}{2 g A^2 P}$$

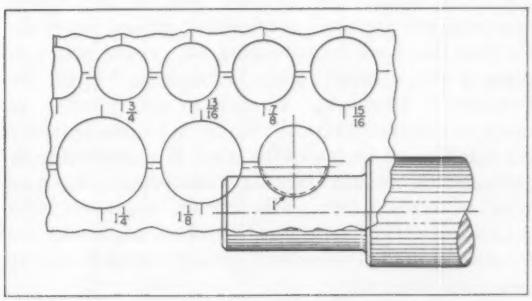
in which the temperature, pressure, and area represent the conditions upstream of the valve.

The K factor for any particular valve may be determined experimentally by simultaneously obtaining values of static pressure, temperature, flow, and pressure drop.

Tips and Techniques

Drawing Woodruff Keys

A circle template can be used to shorten the time required to draw Woodruff keys. Since Woodruff key numbers indicate the width and diameter, a mark is scribed on the appropriate hole of the template to indicate top edge of key. Next, the axial location is determined. Then the template is placed over the drawing with the scribe mark in line with the top of the key and the key is drawn.



Hole sizes already marked on the template are sufficient for identifying the proper hole size for each key size.

As shown in the figure, a circle template is superimposed over a shaft in position for drawing a No. 808 Woodruff key.—VIRGIL E. PETRY, *National Automatic Tool Co., Richmond, Ind.*

Decimal Exponential Equations

These equations look difficult to solve but are really quite simple when logarithms are used in the conventional manner and one operation is added.

Example: Find the value of x, when $x = 0.500^{0.275}$.

Solution: Find log of 0.500,

$$9.69897 - 10$$

multiply by exponent 0.275,

$$2.667216 - 2.75$$

subtract 2.75 from 10.00 to get 7.25, and add as follows:

$$\begin{array}{ll} 2.667216 & -2.75 \\ 7.25 & 7.25 \\ \hline 9.917216 & -10 \end{array}$$

Look up antilog to obtain answer.

$$x = 0.826440$$

—E. HUTCHINSON, *Greenlee Tool Co., Rockford, Ill.*

The Personal Side of Engineering

By **EDWIN C. NEVIS** Personnel Research and Development Corp., Cleveland, Ohio

What Is a Creative Designer?

THE problem of identifying creative persons and of measuring creativity has occupied psychologists and business executives alike for some time. Even before the Sputniks, there was tremendous concern about shortages of trained creative people and the effective utilization of those who possess technical or scientific abilities. Much research has been conducted on problems of defining creativity, development of measures for estimating the potential of individuals, and discovery of conditions conducive to effective problem-solving behavior.

Generally, we tend to think of intelligence or of mental capacity as the best indicator of creativity. Obviously, the more intelligence a person possesses, the more likely he is to do creative work. However, it is frequently noted that many men with high intelligence are not creative, whereas creative performance can be obtained from individuals who are not in the highest levels of intellectual capacity. As indicated in a previous article,[1] the motivation or personality characteristics of the individual will determine whether his basic capacity is used to maximum effectiveness in creative work. Among the studies performed in this area have been several which shed some light on the question of creativity in engineering design activity.

A recent study supported by the Office of Naval Research[2] points up an apparently important factor which is sometimes overlooked in considering requirements for creative performance in design of machines and equipment. Results of this study indicate that rather specific, qualitative factors differentiate creative from noncreative machine designers, rather than sheer level of intelligence.

In this study, a number of tests were developed to discriminate creative from noncreative designers. In this instance, creativity was defined as demonstrated ability to do design work. Trained, functioning engineers were used as the subjects, and their scores on the tests were compared against measures of their creative performance at work. The tests used in this study were of various degrees of vagueness or structure with regard to the design problem presented. Some of them called for specific, more-or-less realistic design problems, whereas others were more abstract, vague or undefined.

Some of the tests used were typical measures of intelligence. Results indicated that general mental ability or level of intelligence did not differentiate between creative and noncreative designers. Furthermore, the results showed that the tests which best predicted creativity were those in which the task appeared to be a practical, realistic one in which the restrictions or specifications for the problem-solving efforts of the person being tested were rather well-defined. In contrast, those tests which were relatively uncontrolled and allowed the engineer to give more "free rein" to his imagination did not differentiate between these two groups.

In other words, it would appear that creativity in engineering design is a highly practical, utilitarian kind of activity. While ingenuity and imagination of a rather high order may be called for, in most machine-design activities the possible combination or organization of machine elements is generally fixed by knowledge of principles of mechanics, materials properties, and the like. The task of the designer is to combine these elements into something new which meets the demands of a specific purpose or application.

It would thus appear that the most effective engineering designers are probably not abstract, symbolic thinkers, and probably don't act as though they were on "Cloud 9." Rather, they are individuals whose ingenuity is in firm touch with practical matters.

This suggests that recruiters and engineering managers might take a good look at the hiring requirements for their engineering design positions. Perhaps we have been looking for people who can make a unique contribution by breaking through the frontiers of knowledge, whereas in reality what we need is a more practical thinker who would apply his intelligence in ingenious ways of recombining or reorganizing already existing knowledge. This may help to explain, too, why certain engineers who do rather well in pure research often are ineffective in process and development activities which require practical ingenuity.

REFERENCES

1. Edwin C. Nevis—"Applying Your Creative Potential," MACHINE DESIGN, Dec. 12, 1957, p. 159.
2. W. A. Owens, C. F. Schumacker, and J. B. Clark—"The Measurement of Creativity in Machine Design," *Journal of Applied Psychology*, 1957, Vol. 41, pp. 297-302.

Charts simplify calculations for moments and deflections of

CIRCULAR ARCHES

By ALEXANDER BLAKE
Section Head
Research Center
Associated Spring Corp., Bristol, Conn.

TO FACILITATE the application of circular arches as machine components, this article presents design equations and graphs for a simplified method of calculating moments and deflections. Arches are treated separately according to three conditions of support. In every case, the arches carry concentrated central loads in the plane of curvature. All the arches are assumed to have uniform cross section, and large radius of curvature relative to radial thickness. Another assumption is that no elastic strain is great enough to alter significantly the circular arch shape.

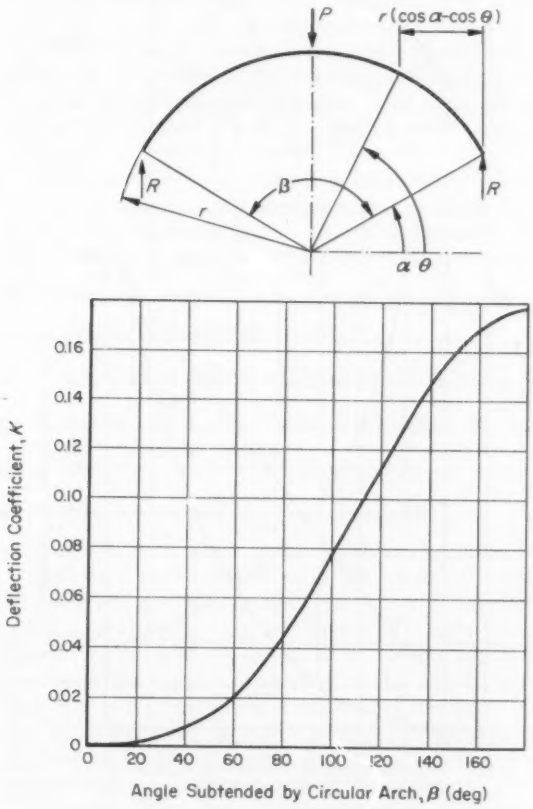


Fig. 1—Simply supported circular arch: Coefficient for calculating vertical deflection

Simply Supported Circular Arch: Since there is no constraint at the supports of this arch, Fig. 1, the reactions are entirely defined by a simple equation of statics. Bending moment can be found at any point of the structure in terms of its geometry and the external load. Note that the behavior of this arch would be the same if one of the supports were hinged and the other mounted on rollers so that it could move freely in the horizontal direction. These two cases are statically determinate structures, and the method of analysis is the same for both.

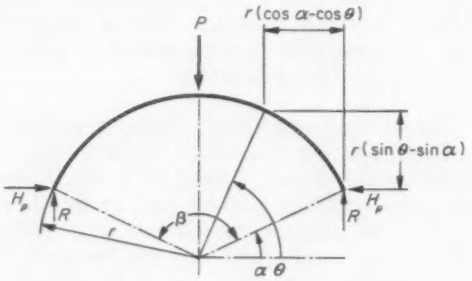
It is also assumed that there are no friction forces,

Nomenclature

E = Modulus of elasticity, psi
H_b = Horizontal thrust on built-in arch, lb
H_p = Horizontal thrust on pin-jointed arch, lb
I = Moment of inertia of arch cross section, in.^{4}
M = Total bending moment, lb-in.
M_o = Fixing couple, lb-in.
P = Concentrated central load, lb
R = Vertical reaction, lb
r = Radius of arch, in.
Y_b = Central deflection of built-in arch, in.
Y_p = Central deflection of pin-jointed arch, in.
Y_s = Central deflection of simply supported arch, in.
α = Complementary angle, rad
β = Angle subtended by circular arch, rad
θ = Angle at which bending moment is considered, rad

Table 1—Strength Equations for Circular Arches

Condition of Support	Simply Supported	Pin-Jointed	Built-in
Source of Factors K	Fig. 1	Fig. 2	Fig. 3
Bending Moment, M, at Section Defined by θ	$Rr(\cos\alpha - \cos\theta)$	$H_p r(\sin\theta - \sin\alpha) - Rr(\cos\alpha - \cos\theta)$ where $\alpha < \theta < (\pi/2)$, and H_p values are equal and opposite	$H_b r(\sin\theta - \sin\alpha) - Rr(\cos\alpha - \cos\theta) + M_o$
Deflection Y under Load, P	$Y_s = (Pr^3/EI)K$	$Y_p = (Pr^3/EI)K_p$	$Y_b = (Pr^3/EI)K_b$
Horizontal Thrust, H	None	$H_p = PK_h$	$H_b = PK_{hb}$
Fixing Couple	None	None	$M_o = -PrK_m$
Equations for Semicircular Arch, i.e., when $\alpha = 0$	$Y_s = 0.1781(Pr^3/EI)$	$Y_p = 0.0189(Pr^3/EI)$ $H_p = 0.318\,P$	$Y_b = 0.0117(Pr^3/EI)$ $H_b = 0.4591\,P$ $M_o = -0.1106\,Pr$



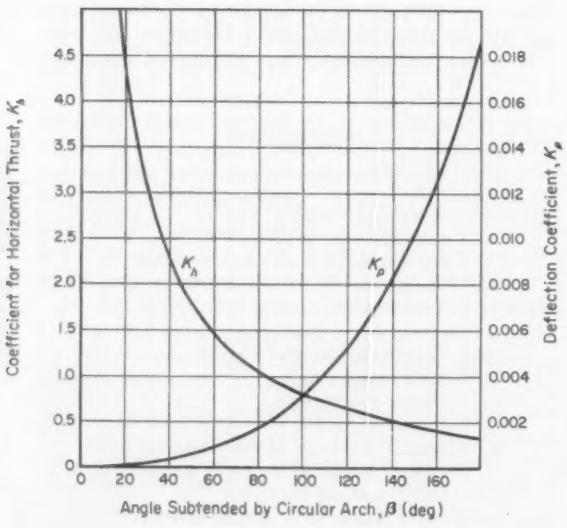
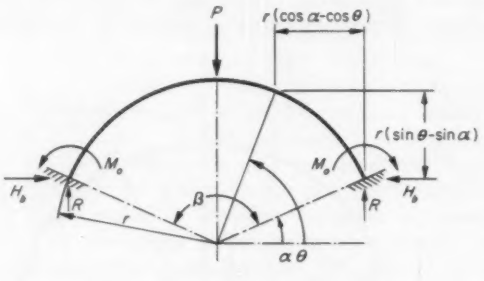


Fig. 2—Pin-jointed circular arch: Coefficients for calculating horizontal thrust and vertical deflection



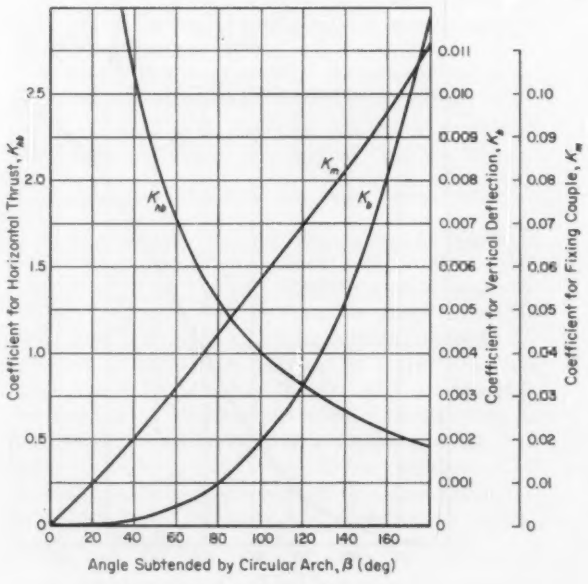


Fig. 3—Built-in circular arch: Coefficients for calculating horizontal thrust, fixing couple, and vertical deflection

between the supporting surfaces and the ends of the arch, which would oppose horizontal movement. In general, this assumption is justified if the structure is fairly rigid and the deflection rather small compared to the length of the arch. However, if thin metallic strips comprise the arch, deflection is *not* small relative to the span of the arch, and horizontal constraint should be taken into account.

EXAMPLE: For a simply supported circular arch, values are: $P = 1000$ lb, $\alpha = \pi/5$ rad $= 36$ deg, $\theta = 2\pi/5$ rad $= 72$ deg, $\beta = 3\pi/5$ rad $= 108$ deg, $r = 50$ in., $E = 28.5 \times 10^6$ psi, $I = 10.7$ in.^{4} Substitution in the bending moment equation for this type arch yields

$$M = \frac{1000}{2}(50)(0.80902 - 0.30902) = 12{,}500 \text{ lb-in.}$$

From Fig. 1, $K = 0.09$. Substitution in the deflection equation yields:

$$Y_a = \frac{1000(50)^3}{28.5(10)^6(10.7)}(0.09) = 0.037 \text{ in.}$$

Pin-Jointed Circular Arch: For this arch, with hinged supports, Fig. 2, the curve of K_h indicates that the theoretical value of H_p increases at a very high rate if there is no yield at the supports and no shortening of the arch due to direct compression. Actually, the horizontal thrust is always lower than the calculated value. In the analysis of this arch, one half the span is treated as an arched cantilever subjected to reaction R and thrust H which act as two statically independent forces. This assumption is justified because the work done by H in line of R is zero.

EXAMPLE: For a pin-jointed circular arch, values are the same as in the preceding examples. From Fig. 2, $K_h = 0.75$, hence $H_p = 750$ lb. Substitution in the bending moment equation for this type arch yields

$$M = 750(50)(0.95106 - 0.58778) - 500(50)(0.80902 - 0.30902) = 1123 \text{ lb-in.}$$

From Fig. 2, $K_p = 0.004$. Substitution in the deflection equation yields

$$Y_p = \frac{1000(50)^3}{28.5(10)^6(10.7)}(0.004) = 0.0017\text{-in.}$$

Built-in Circular Arch: As in the preceding type, symmetry of the built-in arch, Fig. 3, enables mathematical analysis of only one half of the span, considered to be fixed at the point of application and loaded at the support. The effect of the support and the relevant constraining effects is represented by the collective action of R, H_b, and M_o. In the analysis leading to the equations in Table 1, it was assumed that no rotation occurs at the supports.

EXAMPLE: For a built-in circular arch, values are the same as in the preceding examples. From Fig. 3, $K_{Hb} = 0.92$, hence $H_b = (1000)(0.92) = 920$ lb. Also from Fig. 3, $K_m = 0.062$, hence $M_o = -(1000)(50)(0.062) = -3100$ lb-in. Substitution in the bending moment equation for this type arch yields

$$M = 920(50)(0.95106 - 0.58778) - 500(50)(0.80902 - 0.30902) - 3100 = 1111 \text{ lb-in.}$$

From Fig. 3, $K_b = 0.0023$. Substitution in the deflection equation yields

$$Y_b = \frac{1000(50)^3}{28.5(10)^6(10.7)}(0.0023) = 0.0009 \text{ in.}$$

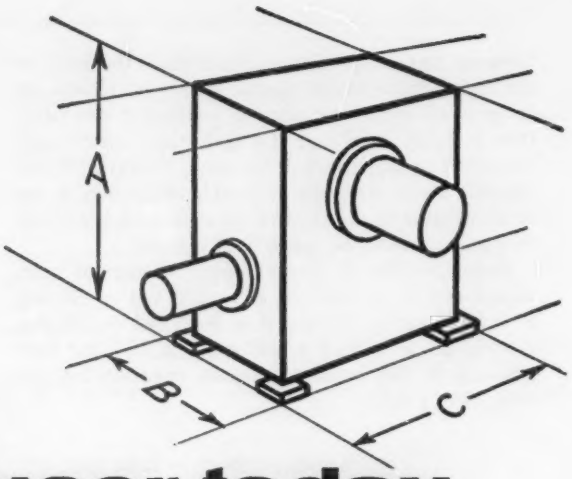
They Say . . .

"A designer, in attempting to be responsible for his fellow man in this way, may without any intention of doing so, put himself in an authoritarian position, in which as a kind of design dictator he is making the decisions for and shaping the lives of a population expected to accept passively the solutions arrived at. This is the design process acting upon people rather than a design process interacting with people. If pursued, it harms the designer by removing him from the two-way relationship that should exist between the artist and his fellow man; harms the user equally by denying him an active role as participant in the experiencing of design." —GEORGE D. CULLER, *associate director, San Francisco Museum of Art.*

"A standard is the unique solution of a repeated task . . . Standards serve the purpose of producing a desired economic value with smaller expenditure than before . . . We measure in order to enlarge human knowledge; we standardize to augment technical order; we manufacture to make more goods available to people . . . Standardization, too, contributes to the fundamentals of cultural advance, exercising, beyond its scientific content, a real social power." — RICHARD VIEWEG, *president, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany.*

"Either we set our scientists to pottering about on the ouskirts of space while we make jealous faces at them behind their backs and go around assuring one another in superior tones that what those fellows are doing is not of any final consequence—or we join with them and as a people remain a living influence in history. Very shortly the choice will be taken out of our hands."—JOHN RAY DUNNING, *dean, School of Engineering, Columbia University.*

Do-It-Yourself...



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Circle 447 on Page 19

DESIGN ABSTRACTS

materials

Steel Castings in Airframes

J. K. Dietz, Chance Vought Aircraft Inc.

A brief discussion of current problems of design and production which are limiting the use of castings in airframes.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 17-20.

Ceramic Coatings for High-Temperature Materials

N. Cannistraro, Bettinger Corp.

A general discussion of ceramic coatings, which includes their mechanical, physical, electrical, and chemical properties. Standard thermal shock tests to determine acceptability of high-temperature coatings are listed. The variety of coatings now available is grouped into three basic types: Coatings for low carbon or low-alloy steels, for stainless steels of either AISI 300 or 400 series, and for superhigh-temperature alloys. Recommended metal preparation procedures and methods of applying the various coatings are covered. Selection of a ceramic coating for a particular high-temperature application is discussed.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 25-36.

Ultrahigh-Strength Chromium Steels

J. C. Hamaker Jr., Vanadium-Alloys Steel Co.

A discussion of the properties of 5 per cent chromium ultrahigh-strength steels at room temperature and low temperatures. Advantages of these steels in certain applications are mentioned and high-temperature properties covered. Methods of hot and cold fabrication and properties of welded sheet are included together with methods of surface protection and relation of properties to heat treatment.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 1-15.

Jet-Age Metals—The High Alloys

H. R. Ogden, Battelle Memorial Institute

A discussion of the availability, properties, and applications of high alloys of chromium, cobalt, columbium, molybdenum, and vanadium.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 11-23.

Machining Characteristics of Aircraft and Missile Alloys

N. Zlatin and L. J. Nowikowski, Metcut Research Associates Inc.

A summary of machining properties of alloys typical of those used in aircraft and missile construction. Alloys include S-816, Inconel X, A-286, SAE 4340 steel, stainless steels at strength levels above 250,000 psi, high-strength titanium alloys, and molybdenum.

ASTE paper 142, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 6 pp.

Steel Forgings For High-Strength Applications

C. E. Moeller, Menasco Mfg. Co.

A discussion of the heat treatment characteristics of steel forgings and other wrought products. Mechanical properties and various heat treatment data are applicable particularly to 4330 and 4340 steels.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 21-29.

Materials For Hypersonic Weapons

J. J. Russ, The Steel Improvement and Forge Co.

A discussion of suitable materials for use in high-mach aircraft in a temperature range from 350 to 1600 F. Materials include aluminum alloys, stainless steels and superalloys, and refractory metals and ceramics. Physical and mechanical properties data of these materials are applicable to high-temperature areas other than in aircraft and missiles.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 31-40.

Embrittlement of High-Strength Steels

E. P. Klier, Syracuse University

A discussion of the various types of failure to which structural steels are subject and the relation of these failures to design practices. Clarification of the term "embrittlement" and its relation to material failures are covered. A theory governing crack nucleation and propagation and its relation to fracture conditions for structures is included. Notch properties and other data pertain to type 4340 steel.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 53-67.

Hafnium—An Atomic-Age Metal

A guide to the properties and potentialities of hafnium for nuclear applications. The metal exhibits a high neutron cross-section plus good corrosion resistance, strength, and ductility. Its most significant advantage in nuclear applications is its freedom from radiation damage. Included are physical and electrical properties of hafnium carbides, hafnium nitrides, hafnium borides, and hafnium silicate.

Advanced Materials Technology, *Volume 1, No. 4, September, 1958; pp. 8-9.*

mechanical

Design for Producibility

C. F. Marschner, Lockheed Aircraft Corp.

A discussion of how to control, in the engineering stages, features of configuration, equipment location, materials utilization, and other factors which insure maximum production rate with minimum deviation from specifications. How design is related to fabrication methods is included, and case histories show the results of applying producibility design principles to actual parts. How to organize for producibility is covered.

ASTE paper 155, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 6 pp.

Optics as an Engineering Tool

A. W. Young, Engis Equipment Co.

A discussion of some recent developments of optical equipment and application of the equipment to engineering problems. Application of the optical equipment is discussed with emphasis on optical tooling systems.

ASTE paper 160, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 6 pp.

Design Features of Steam-Turbine Generators

S. C. Barton, J. A. Massingill, and H. D. Taylor, General Electric Co.

A summary of the progress made in the development of large generators. Development is presented in terms of design features and characteristics of major parts of the generators. Included are discussions on conductor cooling, general design characteristics of liquid cooling systems, insulation for high-voltage coils, methods of spring mountings, and vibration, balancing, and critical speeds.

AIEE paper, 58-1108, AIEE-ASME National Power Conference, Boston, October, 1958; 18 pp.

Design Producibility Of a Magnesium Casting

W. Krzymowski and C. Miller, The Martin Co.

An approach to design producibility by means of a critical review of design criteria, analysis of possible designs, evaluation of design cost, and recommendation as to the best designs. Application of these major steps to an actual casting design is discussed.

Magnesium Association Fourteenth Annual Convention, Detroit, October, 1958; 5 pp.

Economic Design of Light-Alloy Castings

P. A. Broadbent

Design considerations for light-alloy castings which are not always apparent to the designer, production engineer, or foundryman. Discussion covers choice of alloys, rib design, cast inserts, screw threads, corrosion, and how to redesign a component for casting in light alloys. Mechanical properties of sand casting alloys are covered.

From a paper prepared for the Institution of Mechanical Engineers (Great Britain); 11 pp.

processes

Precision Forgings

A. G. Jones, North American Aviation Inc.

A discussion of the status of the art of precision forgings. Comparisons of precision forgings and conventional forgings are included and some design considerations and economies mentioned.

ASTE paper 174, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 5 pp.

Fabrication of Refractory Metals

W. L. Bruckart, Universal-Cyclops Steel Corp.

Basic data on properties and availability of columbium, molybdenum, tantalum, rhenium, and tungsten. General characteristics, fabrication methods, and applications of each are covered. Welding data for refractory metals and brazing materials for molybdenum and tungsten are listed.

ASTE paper 177, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 26 pp.

Cold-Roll Forming of Semiaustenitic Stainless Steel

F. Jacobs, Temco Aircraft Corp.

A description of the cold-roll forming process, its applications and limitations. Design considerations are included and mechanical properties of various materials before and after rolling are mentioned. Physical and mechanical properties of roll-formed stainless steel sheet and plate are tabulated.

ASM paper, Proceedings of the First Southwestern Metal Conference, Dallas, Tex., 1958; pp. 51-68.

Ultrasonic Welding Techniques

J. B. Jones and W. C. Potthoff, Aeroprojects, Inc.

A discussion of typical applications of ultrasonic welding and types of basic welding equipment available. Strength of ultrasonic single-spot welds in aluminum, mild steel, stainless steel, molybdenum, Inconel, titanium, and Zircaloy-2 are included. Welding equipment designed for specific component geometry is discussed.

ASTE paper 152, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 8 pp.

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ASM—American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

Advanced Materials Technology, The Carborundum Co., New Products Branch, Research & Development Div., Niagara Falls, N. Y.

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

The Magnesium Association, 122 East 42nd St., New York 17, N. Y.

The Institution of Mechanical Engineers 1 Birdcage Walk, Westminster, London, SW 1.

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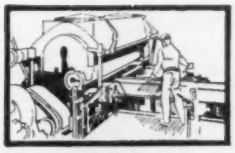
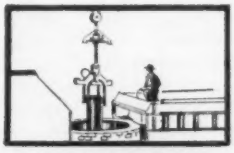
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.



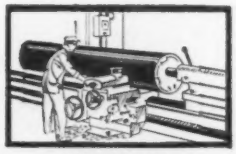
SPINNING

ACIPCO tubes are centrifugally spun to exact physical and metallurgical specifications. Thus, the exact size and metal analysis your process or project requires is assured.



HEAT TREATING

Modern equipment for uniform, controlled heat treating and quenching is an ACIPCO advantage for users of steel tubes where specific physical, mechanical and other metal properties are required.



MACHINING

ACIPCO'S machine shop, one of the South's most completely equipped, performs a full range of machine shop operations including turning, boring, drilling, facing, grinding, metallizing, polishing and honing.

FABRICATION

Complete, integrated facilities for machining, welding, finishing and heat treating of tubular parts save time and expense for ACIPCO customers.

TECHNICAL ASSISTANCE

A staff of highly trained engineers, metallurgists, chemists, and craftsmen is available to designers and manufacturers who specify ACIPCO spun tubes.

Special Products Division

AMERICAN CAST IRON PIPE CO.

PHONE AL 1-8121, EXT. 285 • BIRMINGHAM, ALA.

Circle 448 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Capacitors

Dimensions, ratings, and application data on alternating current drawn-case capacitors for use in air conditioning, business machines, refrigeration, industrial control, submersible pumps, and fan motors are contained in Bulletin GEA-6789. Ratings range from 1 to 50 mfd at 165 to 440 v ac. 2 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 501 on Page 19

Power Transmission Equipment

Sheaves, variable-pitch sheaves, V-belts, flat-belt pulleys, pillow blocks, flange units, take-up bearings, couplings, and timing-belt drives are some of the wide variety of power transmission equipment described in Bulletin 3101. Dimensions and performance data are given on each item. 8 pages. T. B. Wood's Sons Co., Chambersburg, Pa. E

Circle 502 on Page 19

Pipeline Aftercoolers

Steel shell construction, removable tube bundle, counter current flow design, and an advanced centrifugal moisture separator are features of the A-100 line of Ross pipeline aftercoolers described in Bulletin 302.6K1. Specs cover 54 models with up to 125 psig operating pressures. 8 pages. American Standard, Ross Heat Exchanger Div., Buffalo 5, N. Y. N

Circle 503 on Page 19

Cathode Counting Tube

The Dekatron is a cold cathode tube for counting at up to 20,000 cps. Glowing spot moves around its periphery to indicate digits 0 through 9 on its surrounding bezel or face. Technical data and specifications on this tube are given in Technical Data Sheet IC 4001. 2 pages. Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass. B

Circle 504 on Page 19

Directional Control Valve

Three types of solenoid controlled directional control valves with flow capacities to 3½ gpm and operating pressures to 1000 psi are described in illustrated bulletin. These four-way valves are designed to control flow to and from double-acting cylinders or fluid motors. 2 pages. John S. Barnes Corp., Rockford, Ill. K

Circle 505 on Page 19

Measurement & Control

Instruments for shock, vibration, inertial control, temperature, and other devices for use as single components or in complete systems are detailed in bulletin "Measurement and Controls." Described are transducers, amplifiers, cables, connectors, vibrators, interferometers, strain gages, accelerometers, temperature probes, and miniature airborne recorders. 4 pages. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. D

Circle 506 on Page 19

Heat Exchangers

Engineering and performance data on shell and tube heat exchangers are given in Catalog 1258. Offered in copper base alloy, steel, and stainless steel, these single and multiple pass units are suited for a wide range of applications from simple heating or cooling of liquids to processing operations. 16 pages. Young Radiator Co., Racine, Wis. K

Circle 507 on Page 19

Motor Prices

Form No. 943 contains price and operating information on squirrel-cage induction, wound-rotor induction, direct current, gear, single phase, split phase, capacitor start, repulsion start, and specific purpose electric motors. Prices of controls are also listed. 4 pages. Century Electric Co., 1806 Pine St., St. Louis 3, Mo. I

Circle 508 on Page 19

Plastic-Lined Valves

Penton plastic-lined diaphragm valves are adaptable for a wide range of chemical services at temperatures to 300° F. Bulletin No. 114 tabulates performance characteristics of these ½- to 6-in. valves and also lists chemical resistance of lining to many chemicals. 4 pages. Hills-McCanna Co., 4600 W. Touhy Ave., Chicago 46, Ill. I

Circle 509 on Page 19

Fluid Power Equipment

Variable delivery, constant delivery, and automatic feed pumps; constant and variable displacement motors; variable speed transmissions; hydraulic cylinders; servo components; and valves and accessories are among the fluid power equipment described in Bulletin 10051-G. Complete performance data and specs are listed. 12 pages. Oilgear Co., 1570Q W. Pierce St., Milwaukee 4, Wis. K

Circle 510 on Page 19

Fusible Panelboards

Details of a new line of quick-make quick-break fusible switches and panelboards are contained in Bulletin 3-230. Ratings range from 30 through 1200 amp and 250 through 600 v. Chart gives standard cabinet heights and layout instructions and shows at a glance what panelboards are needed for a specific job. 8 pages. Federal Pacific Electric Co., 50 Paris St., Newark, N. J. C

Circle 511 on Page 19

Running Gear

Offered as a design guide to casters and suspension systems, bulletin entitled "Modern Caster" discusses casters, floor and wheel brakes, undercarriages, and industrial wheels. Design considerations for mobile equipment are covered, and full specifications are given for all casters and wheel units. 16 pages. Modern Caster Co., Rockford, Ill. K

Circle 512 on Page 19

Bronze Bars

Available in 105-in. lengths, Continucast bronze bars are made in 21 sizes of solid bronze from ½ to 3-in. diameter and 118 sizes of tubular bars which range from ½ to 2½ in. ID and from 1 to 3 in. OD. Physical properties and other information are given in Bulletin JBL-14. 4 pages. Johnson Bronze Co., New Castle, Pa. G

Circle 513 on Page 19

Laminated Plastic

"Formica—Stronger than Steel; Lighter than Aluminum" is title of Catalog S-52 which describes design and production advantages of this laminated plastic that is particularly suited for tooling and metalforming applications. Properties are tabulated. 4 pages. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio. G

Circle 514 on Page 19

Air & Hydraulic Cylinders

Bulletins A-100 and H-100 respectively deal with Series A Milwaukee heavy-duty air cylinders and Series H Milwaukee hydraulic cylinders. The air units are rated to 200 psi and offered in 1½ to 14-in. bore sizes. Hydraulic cylinders in 1½ to 12-in. bore sizes are rated 2000 to 3000 psi. 8 pages each. Milwaukee Cylinder Co., 5757 S. Pennsylvania Ave., Cudahy 7, Wis. K

Circle 515 on Page 19

Electrical Impulse Counters

Elmeg electromagnetic impulse counters for both reading and printing are described and specified in small booklet. Units are principally designed for DC operation up to 60 v. Standard units operate at counting rates up to 10 impulses per sec. Maximum of 50 impulses per sec is possible in special types. 28 pages. Presin Co., 2014 Broadway, Santa Monica, Calif. L

Circle 516 on Page 19

DETACHABLE MOTOR DESIGN
permits motor change in minutes
— avoids downtime for motor repairs.

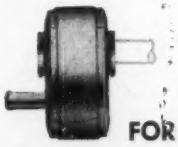
Now - a MOTORIZED SPEED REDUCER FOR MOUNTING DIRECTLY ON SHAFT the NEW

BOSTON Gear® OPTIMOUNT™

TRADEMARK

IT'S THE NEW OPTIMOUNT

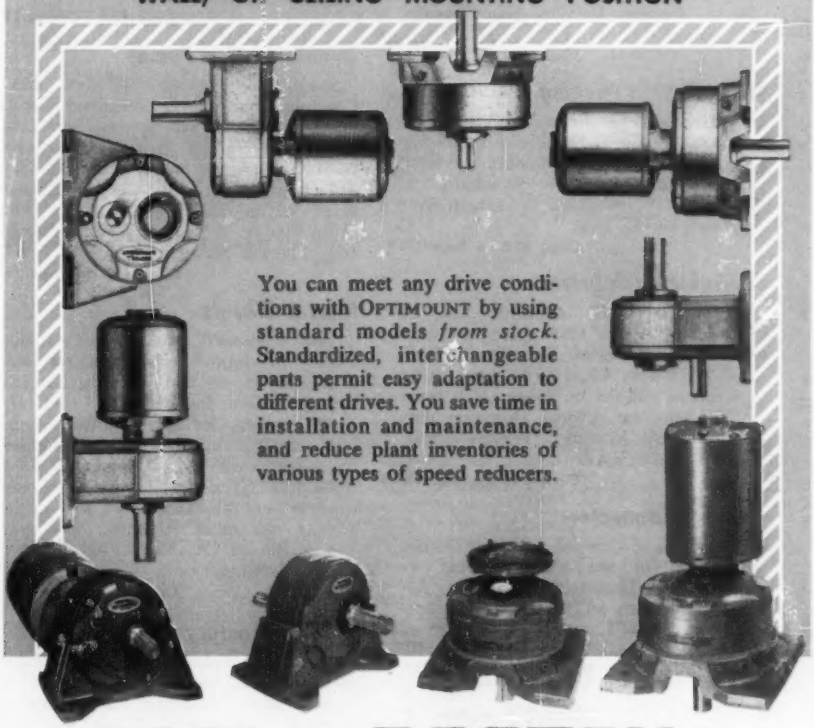
Ratiomotor for shaft mounting. It's the compact power package you have needed to save space without sacrifice of top transmission efficiency. Single or double reduction helical geared units deliver 87.4 to 431 output RPM. Get details—find out how OPTIMOUNT can solve your drive design problems.



HELICAL GEARED
REDUCTORS • RATIOMOTORS
AND FLANGED REDUCTORS

FOR SHAFT-MOUNTING . . .

OR IN STANDARD BASES FOR ANY FLOOR, WALL, OR CEILING MOUNTING POSITION



You can meet any drive conditions with OPTIMOUNT by using standard models *from stock*. Standardized, interchangeable parts permit easy adaptation to different drives. You save time in installation and maintenance, and reduce plant inventories of various types of speed reducers.

OPTIMOUNT delivers maximum power, with highest efficiency, through precision-finished helical gearing made to BOSTON Gear quality standards. Get details from your Distributor. He will demonstrate the many features that assure OPTIMUM PERFORMANCE. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

66 MODELS
FROM STOCK

680 OPTIONAL MOUNTING ARRANGEMENTS

1/6 to 15 H.P. DRIVES

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

INDUSTRIAL DISTRIBUTORS THE RIGHT HAND OF PRODUCTION

CALL YOUR **BOSTON Gear DISTRIBUTOR**

NEW CATALOG OP-1 lists complete OPTIMOUNT data—selection charts, application information.

Remember — STANDARDIZATION PAYS —®

Stainless Fittings

Complete dimensional guidance on the full line of Tube-Turn stainless steel welding fittings and flanges is provided by Catalog TT600. Technical data presented include allowable S-values, allowable working pressures, pressure-temperature ratings, and corrosion resistance. 54 pages. Chemtron Corp., Tube Turn Div., Louisville 1, Ky. G

Circle 517 on Page 19

Air Cylinders

Squair Head cylinders are designed for use with air, but they are adaptable to oil for low pressure service. Mounting dimensions and application information are given on these 1½ to 8-in. bore units in Bulletin SQ 10-58. They are interchangeable with all JIC cylinders. 6 pages. Tomkins-Johnson Co., Jackson, Mich. H

Circle 518 on Page 19

Electric Controls

Production facilities of this company in the design and production of custom-built electric controls ranging from small subassemblies to large automation controls are described in illustrated bulletin. 4 pages. Electrol Specialties Co., 441 Clark St., South Beloit, Ill. K

Circle 519 on Page 19

Potentiometer Hardware

Specification sheet TPH/J/8 illustrates a variety of mounting hardware for Trimpot and Trimit potentiometers. Hardware adapts these lead screw actuated electronic units to practically any mounting situation. 2 pages. Bourns Laboratories, Inc., Box 2112, Riverside, Calif. L

Circle 520 on Page 19

Weatherproof Motors

Illustrated Bulletin 2550 presents details on weather-protected motors of 250 to 2000 hp. They require no additional housing or protection. Ratings, specifications, design features, and cutaway views are included. 6 pages. Louis Allis Co., Milwaukee 1, Wis. K

Circle 521 on Page 19

Welding Fittings & Flanges

Dimensional and physical data on 3-in. nominal pipe size welding fittings and forged steel flanges are found in Technical Bulletin FDC-259. Details of various types available are given. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Milwaukee 46, Wis. K

Circle 522 on Page 19

Dampers & Operators

Dampers of many types and sizes for diverse applications are described in illustrated Catalog C101-3. Damper motors covered include a wide variety of electric and pneumatic models for two-position, floating, or proportioning service. Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa. E

Circle 523 on Page 19

Instrument Bearings

Line of thin-section instrument bearings, made in precision and ultraprecision grades to dimensions of the AFBMA B-500 Series is described in illustrated Catalog 59. T-series includes 12 sizes from 0.6250-in. bore and 1.0625-in. OD to 3.0625-in. bore and 3.8750-in. OD. Details of five types are given. 24 pages. MPB, Inc., Split Ballbearing Div., Lebanon, N. H. B

Circle 524 on Page 19

Flexible Metal Hose

Instructions on how to install all types of flexible metal hose properly in order to secure the longest service are offered in illustrated Bulletin N14A. Eight diagrams explain correct use of flexible connections to compensate for misalignment and to eliminate vibration transmission. 2 pages. Korfund Co., 48-19D 32nd Place, Long Island City 1, N. Y. D

Circle 525 on Page 19

Flexible Gear Coupling

Descriptive data on the Nyflex lightweight flexible gear coupling with a nylon sleeve are content of Folder N-1. Tabular data cover horsepower, speed ranges, and available bore sizes. 4 pages. Sier-Bath Gear & Pump Co., 9254 Hudson Blvd., North Bergen, N. J. D

Circle 526 on Page 19

Speed Reducer

Mounting for top, bottom, vertical, sidewall, or angled drive of Verso worm gear speed reducers is described in illustrated Bulletin 5018. Horsepower and torque data are included. Speed reduction ratios range from 70:1 to 5:1. Dimensions of various models are diagrammed and tabulated. 4 pages. DeLaval Steam Turbine Co., Trenton 2, N. J. C

Circle 527 on Page 19

Compression Packing

Wall chart highlights the proper application of Val-Pac rod and sheet type compression packings. Product for eight basic types of service is pinpointed. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 528 on Page 19

Variable Pitch Drives

Specifications of extensive line of Browning variable pitch drives are contained in illustrated Bulletin V-183-B. Two types with 4.9 to 9.7-in. pitch range for R-belts and 4.9 to 11.0-in. pitch range for W-belts are covered. Selection data are included. 12 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 529 on Page 19

Coaxial Connectors

TM Series of threaded miniature coaxial connectors for precision equipment are detailed and illustrated in catalog. Included are plugs, jacks, receptacles, adaptors, and caps. Cable assembly instructions are given. 8 pages. General RF Fittings, Inc., 702 Beacon St., Boston 15, Mass. B

Circle 530 on Page 19

High Temperature Cables

Simconex silicone-insulated cables for high temperature operations (up to 392° F) are subject of Technical Bulletin 1032. They retain flexibility at low temperatures, and resist moisture, ozone, and corona. Application, physical, and chemical properties data are included. 12 pages. Simplex Wire & Cable Co., Cambridge 39, Mass. B

Circle 531 on Page 19

Conveyor Belts

Heavy duty Koroseal conveyor belts, for use in contact with cutting oils and greases, or where they must handle wet and sticky materials, are subject of Bulletin 2470. Belts are smooth, nonporous, and nonmarking. 2 pages. B. F. Goodrich Industrial Products Co., Akron, Ohio. F

Circle 532 on Page 19

Retaining Rings & Tools

Assembly tools Catalog AT 10-58 contains engineering dimensions and specifications for Waldes Truarc retaining rings, applicators, dispensers, and grooving tools. It features a 20-ring selector guide and describes internal, external, universal, and angle-tip pliers, as well as tools for applying grip rings. 16 pages. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y. C

Circle 533 on Page 19

Control Cable

Folder on plastic insulated and jacketed control cable rated 600 v lists specs for small diameter, station, flexible, and supervisory control cables with 2 to 19 conductors. IMSA municipal signal cables with 3 to 12 conductors are also listed. 6 pages. Chester Cable Corp., 237 Oakland Ave., Chester, N. Y. D

Circle 534 on Page 19

Double Suction Pumps

Specifications, a sectional view, selection table, and outline dimensions relative to DMB and DB ball bearing, horizontal split case, double suction centrifugal pumps for general water service are furnished in Bulletin 251. Capacities range from 500 to 5000 gpm at heads from 20 to 300 ft. 6 pages. Warren Pumps, Inc., Warren, Mass. B

Circle 535 on Page 19

Rims & Wheels

Well illustrated, multipurpose Catalog S-8811 on rims, wheels, tools, and rim accessories covers rim research, step-by-step procedure for mounting and demounting rims, and operating instructions for using hydraulic tools. Rims specified include tubeless and demountable truck types, tube types, rims for industrial and construction machines, and for earth-moving equipment. 80 pages. Goodyear Tire & Rubber Co., Metal Products Div., Akron 16, Ohio. F

Circle 536 on Page 19

Silica Refractory Material

A practical operating range of −450 to 2200° F is featured by Foamsil, a foamed silica insulating and refractory material. Consisting of 99 per cent pure fused silica, material is unaffected by all common acids as well as thermal shock. Physical characteristics and possible uses are outlined in folder FS-1. 4 pages. Pittsburgh Corning Corp., One Gateway Center, Pittsburgh 22, Pa. F

Circle 537 on Page 19

TEN-TO-ONE THE
Copper Clad Laminate
YOU WANT IS HERE!

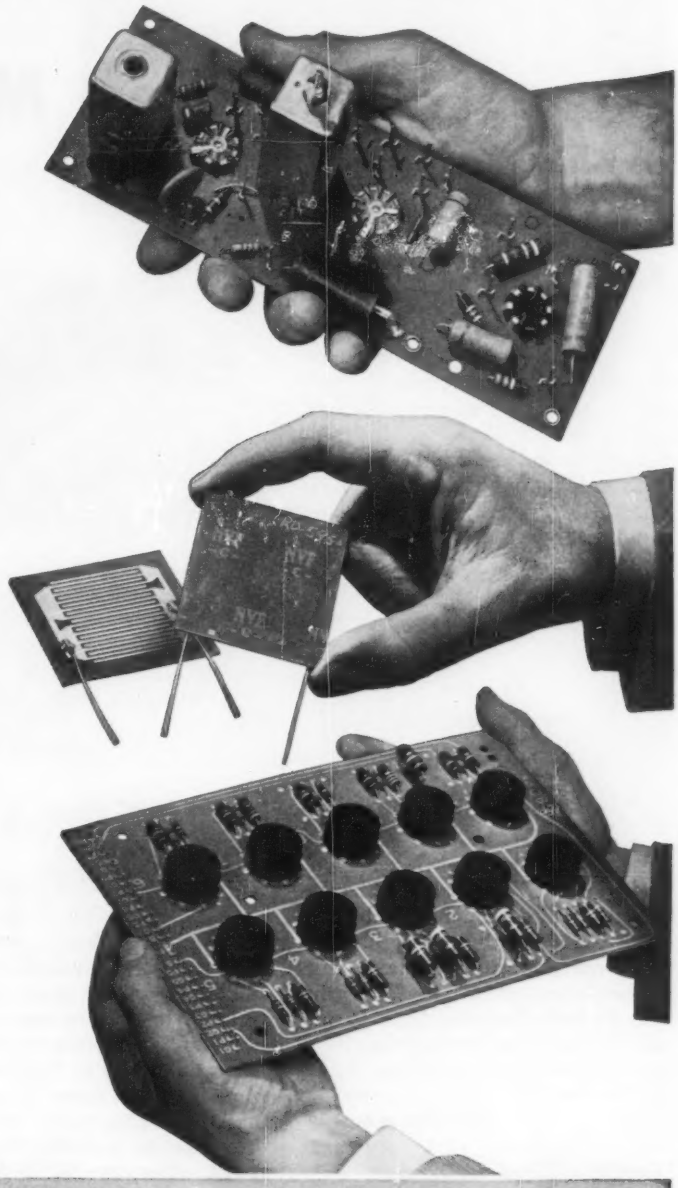
From these ten basic PHENOLITE® Grades, you can select the base material, resin, properties and price to fit your present printed circuit need.

If your problem is finding a suitable cold-punch material, try samples of XXXP-470-1. It's designed for use in automated production equipment. If you are looking for higher heat resistance, check Grades G-10 and G-11.

Out of National's research laboratories come new advances every day. See your National Representative about new products and applications. He can keep you posted on the full line of PHENOLITE Laminated Plastic, Vulcanized Fibre and National Nylon for electronic applications across-the-board. In the meantime, write for our new "PHENOLITE Copper Clad Data" folder. Address Dept. G-12.

NATIONAL
VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario



TYPICAL TEST VALUES ON COPPER CLAD PHENOLITE

GRADE	PROPERTIES OF BASE MATERIAL					COPPER CLAD PROPERTIES				RELATIVE COST
	Dielectric Constant	Dissipation Factor	Moisture Absorption	Flexural Strength	Maximum Operating Temperature	Copper Bond Strength		Hot Solder Resistance	Surface Resistance	Based on XXXP on Arbitrary Scale of 1
	10^3 Cycles	10^6 Cycles	1/16", % 24 Hrs	Psi	Degree F	Pounds to Pull 1" Strip		Secs to Blister 1" Square > Greater Than	Megohms, Etched Reima Comb Pattern, 96 Hrs/35°C/90% RH	1/16" Thk. 1 Oz. Copper 1 Side
						1 Oz	2 Oz			
P-214-B-1	5.3	.040	2.20	18,000	250	8	11	>10@ 475°F	100,000	.81
XXP-209-G-1	4.6	.037	1.30	17,000	250	8	11	>10@ 475°F	200,000	.92
XXP-239-1 PHENOCLAD	4.2	.035	0.67	15,500	250	8	11	>10@ 475°F	200,000	.92
XXXP-219-C-1	4.5	.030	0.70	15,500	250	8	11	>10@ 475°F	500,000-1,000,000	1.00
XXXP-455-1	4.0	.026	0.55	23,500	250	8	11	>10@ 475°F	1,000,000-1,500,000	1.00
XXXP-470-1	3.7	.027	0.48	14,000	250	8	11	>10@ 475°F	300,000-500,000	1.00
N-1-852-1	3.3	.030	0.20	16,000	165	8	11	>10@ 450°F	2,000,000	2.69
G-5-813-1	6.8	.018	1.00	55,000	300	8	11	—	—	2.98
G-10-865-1	5.2	.012	0.13	60,000	250	10	15	>30@ 500°F	1,500,000-2,000,000	3.49
G-11-861-1	4.9	.015	0.17	60,000	300	10	15	>30@ 500°F	2,000,000	3.55

Circle 450 on Page 19

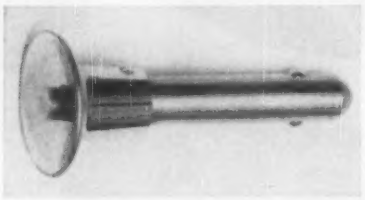
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Quick-Release Pins

for tension and shear-load applications

BB-Pins have a recessed head which protects release button against accidental release. Internal rod which provides positive lock for balls unlocks only when button in head is intentionally depressed during installation or removal. Locking rod, activated by silicone, is vibrationproof and corrosion and temperature resistant. The quick-



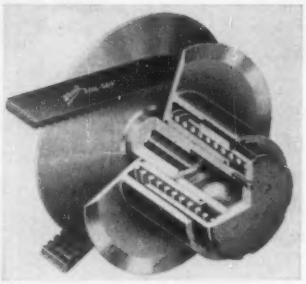
release pins are used for tension and shear-load applications. Shanks are gun-drilled solid bar, and have thick walls for high strength. Pins are available in stainless and chrome-alloy steels in all grip lengths and diameters from ¼ in. up. **Waldick Engineering Co.**, P.O. Box 398, Huntington Station, L. I., N. Y. D

Circle 538 on Page 19

Variable-Speed Sheaves

will not corrode, freeze, or stick

Design of MS series variable-speed sheaves eliminates fretting corrosion as well as freezing and sticking. Bearing surfaces are reoiled from an oil reservoir with each rotation of pulley. Continuous rotational pumping action of flange hub on sleeve renews and evenly distributes oil film on bearing surfaces. Nylon-faced rubber keys, located outside bearing surfaces, transmit power from stationary to moving flange through a removable sleeve cap. Keys also assure



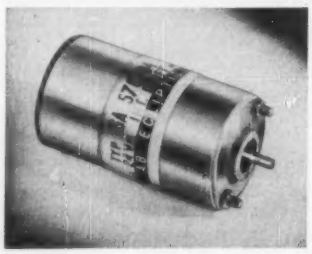
even distribution of load and equal transmission of power by both flanges. Series consists of five pulleys, rated at 2, 3, 5, 10, and 15 hp, at maximum pitch diameter. **T. B. Wood's Sons Co.**, Chambersburg, Pa. E

Circle 539 on Page 19

Reversible DC Motor

has speed range of 3000 to 20,000 rpm

Two-lead, reversible dc motor with air-stabilized Alnico permanent-magnet field is available for 6, 12, 24, 28, 32, or 48-v input. It is rated at 1/150 hp for continuous duty or 1/75 hp in intermittent duty, and has speed range of 3000 to 20,000 rpm. Body of motor is precision-machined aluminum, with anodized finish available in various colors, silver, or black. Armatures are dynamically balanced. Extra output dc generator winding is provided for tachometer-generator or control circuits. Frame dimensions are 1.3 in. diam x 2.4 in. length, with over-all length of 2¾ in. including shaft extension. Weight is



approximately 6 oz. **Carter Motor Co.**, 2719A W. George St., Chicago 18, Ill. I

Circle 540 on Page 19

Expanded Titanium Sheet

in 0.050 to 0.125-in. gages

Expanded titanium sheet for use in plating and chemical industries is available in gages from 0.050 to 0.125 in., into ½ to 1½ in. diamonds, in standard 48 x 96-in. sheets. Material can be bent over a radius four times the metal thickness in either longitudinal or transverse direction after sandblasting and pickling. Annealing does not improve bend factor. Expanded sheet is available in unflattened or flattened mesh, with flattened mesh primarily for decorative purposes. Material has extreme resistance to corrosion. **Mallory-Sharon Metals Corp.**, Niles, Ohio. G

Circle 541 on Page 19

Miniature Potentiometer

panel-mounted unit operates from −65 to 175 C

Trimpot Model 223 lead-screw actuated potentiometer combines panel mounting with high temperature and humidity-proof characteristics. Weighing about 0.3 oz and measuring only 0.23 x 1.32 x 0.24 in., unit can be mounted through a single 0.2-in. diam hole. Threaded adapter extends through panel hole and is secured by a hex nut. Available resistances are from 100 to 50,000 ohms, and power rating is 1 w at 70 C. Unit operates reliably from −65 to 175 C. Potentiometer

Quietest Direct Drive Blower Motor

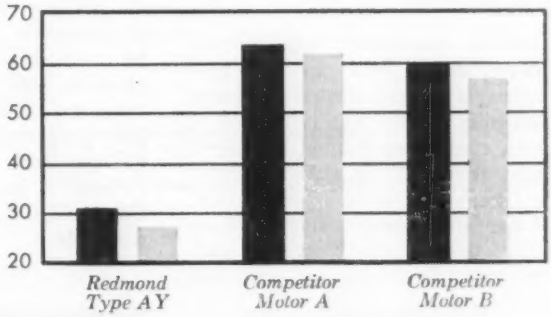
Place a mechanic's stethoscope on the end cap and you can easily hear the difference between the newly-designed Redmond Type AY and motors of conventional design. Try it on a Redmond 1/6 hp—the noise level is about that of a 1/35 hp motor of conventional design.

New Redmond Design Reduces Blower Vibration to One-Fifth that of units using Conventional Shaded-Pole Motors

Apply vibration tests and you will be quick to agree that here is the quietest direct-drive blower motor available. The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The graph shows vibration test results on the new Redmond design and two competitive motors. These tests were made with the best vibration testing equipment available. The solid black bar shows vibration on the motor end cap; the gray bar shows vibration on the blower housing. The graph is decibel readings on 120 cycles, since the 120 cycle frequency is the one that is the basic source of nearly all noise problems. Reduction of vibration is a logarithmic function—the reduction of vibration in the Redmond motor to 33 decibels reduces noise to only 1/5th that of conventional motors.

The new AY is ideal for a wide variety of applications requiring a whisper-quiet, economical, high-quality motor. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.



The Standard of Dependability

CC Redmond COMPANY, INC.

Subsidiary of **CONTROLS COMPANY OF AMERICA**

OWOSSO, MICHIGAN

REDMOND

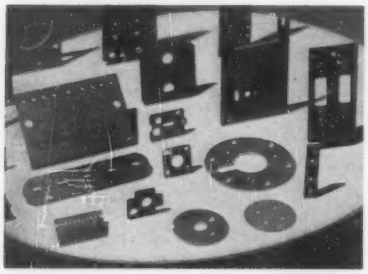
Circle 451 on Page 19

meets requirements of MIL-STD-202A. **Bourns Laboratories Inc.**, P.O. Box 2112, Riverside, Calif. L

Circle 542 on Page 19

Phenolic Laminate

has high impact and flexural strength



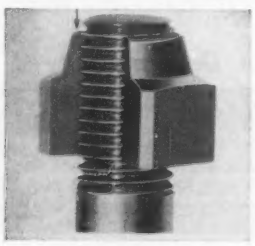
No. 4012-42 Lamicoid is a punching grade phenolic laminate which combines excellent electrical properties with high impact and flexural strength. Laminate has high-quality, phenolic-resin-impregnated paper base with reinforcing element. Material is readily machined and can be punched into intricate parts with conventional equipment. Applications include electronic terminal boards containing a number of components and exposed to high mechanical stress, and base material for printed circuits formed by electrical deposition. **Mica Insulator Div., Minnesota Mining & Mfg. Co.**, Schenectady 1, N. Y. C

Circle 543 on Page 19

One-Piece Lock Nut

reusable unit has high fatigue life

Conelok one-piece, reusable prevailing-torque lock nut has three sectors of tapered portion preformed inwardly. When nut is applied to bolt, conforming sectors are elastically returned to a circular configuration and create inward and downward pressure which produces intimate contact between load-carrying flanks of nut and bolt threads. Shape of cone sector displacement insures conformity with mating bolt and maximum friction contact area. Closed stress path in locking portion of nut and distribution of locking pressure produce a unit with high fatigue life. Nut is adaptable to high as well as low-torque assemblies, and particularly to high-torque stop-nut applications, permitting use of hardened nuts with bolts of softer material. **National Machine Products Co.**, Utica, Mich. H



Circle 544 on Page 19

In-Line Solenoid Valve

has pressure ratings up to 4500 psi

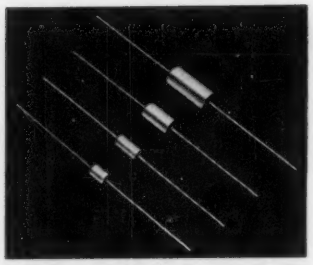
Series V-27200 in-line solenoid valve handles cryogenic fluids, ethylene oxide, jet fuels, high-pressure pneumatics, liquefied gases, and hydraulic oils in temperature range from −320 to 500 F. Valve has Teflon bubbletight sealing and pressure ratings up to 4500 psi. Media contacts are Teflon, stainless steel and electroless nickel-plated steel. Unit provides a choice of orifice sizes, with variations available for operation from 750 psi with 0.125-in. orifice to 4500 psi with 0.020-in. orifice. Two and three-way and diverter configurations are available. Response is 15 millisec, and voltage ranges from 1 to 30 v dc. **Valcor Engineering Corp.**, 5370 Carnegie Ave., Kenilworth, N. J. D

Circle 545 on Page 19

Subminiature Capacitors

solid tantalum units for use at −55 to 125-C temperatures

STA solid tantalum capacitors are available for electronic applications requiring small size, high capacitance, and extended operating temperatures. Units can be supplied in



ranges of 0.0047 to 330 mfd, from 6 to 60 v, with maximum stability and reliability at temperatures from −55 to 125 C. Units consist of a porous tantalum anode with formed tantalum-oxide dielectric, sealed in silver-plated metal case. Glass-to-metal seal affords full protection against moisture or low pressures encountered at high altitude. Capacitors are furnished in four case sizes. They are suited to transistor circuitry in both military and commercial applications. **Fansteel Metallurgical Corp.**, Dept. MDC, North Chicago, Ill. J

Circle 546 on Page 19

Adjustable-Speed Drives

⅛ through ¾-hp units have 8:1 speed range

V-S Jr. adjustable-speed drives are designed for units such as small conveyors, grinders, printing presses, welding positioners, packaging machines, light winders, blueprint machines, and small agitators. The new ⅛ through ¾-hp units have 8:1 speed range, with larger speed ranges obtainable for intermittent duty or light loads. Units incorporate a single half-wave thyratron electronic tube as main rectifier, and operate on standard single-phase, 50 or 60-cycle, 220-v ac power. Control unit can be mounted directly on driven machine or at some remote location. Control panel is built around a printed-circuit board, virtually eliminating wires and soldered connections.

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

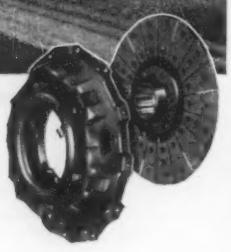
- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

ROCKFORD



MORLIFE® CLUTCHES

Insure SMOOTH Powerful Pick-Up in Heaviest Going

Compared to previous type clutch facings, Morlife® Clutch facings reduce foot pedal pressure up to 50%. They assure positive engagement—with power-holding grip. Provide a degree of heat resistance and dissipation never before available. They give several times the durability for prolonging clutch life and extend the time between pedal adjustments many times as long. Let ROCKFORD clutch engineers show you how these new advantages will improve the operating ease and prolong the on-the-job life of *your* product.

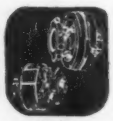
Small Spring Loaded

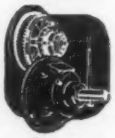
Automotive Spring Loaded

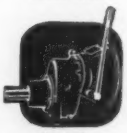
Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center


Light Over Center


Power Take-Offs


Speed Reducers

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD B-W BORG-WARNER

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

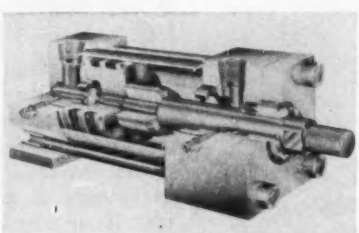
Drive motors are available in drip-proof, totally enclosed nonventilated, totally enclosed fan-cooled, or explosionproof enclosures. **Reliance Electric & Engineering Co.**, 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 547 on Page 19

Air Cylinder

square-head unit is interchangeable

Squair-Head interchangeable air cylinder is designed to produce maximum force with minimum pressures, and is adaptable to use of low-pressure oil as working medium. Cylinder is available cushioned or noncushioned, and is furnished in nine standard bore diameters from 1½ to 8 in. Unit utilizes up to 200 psi air or 50 psi oil pressure, and is interchangeable with all standard JIC cylinders. Features include solid steel heads and mounting plates, hard chrome-plated bodies and piston rods, and metallic rod scraper. **Tomkins-Johnson Co.**, Jackson, Mich. H



Circle 548 on Page 19

Industrial Wheels

have synthetic urethane elastomer tread

Duralast industrial wheels are available with straight or tapered roller bearings in sizes from 4-in. diam up. Tread material is a synthetic urethane elastomer developed for industrial-wheel application on floor trucks and similar equipment. It is hard and abrasion resistant, without sacrificing elasticity or resilience. Material is chemically inert, nonmarking, nonconductive, and is resistant to oil, water, grease, brine, and most industrial solvents. Recommended temperature range is −40 to 200 F. Casters and wheels combine long tread life and heavy load-carrying capacities of

metal and plastic wheels with noiseless, floor-protective qualities of conventional rubber. **Hamilton Caster & Mfg. Co.**, 1700 Dixie Highway, Hamilton, Ohio. G

Circle 549 on Page 19

Blended Teflon Material

has excellent resistance to wear

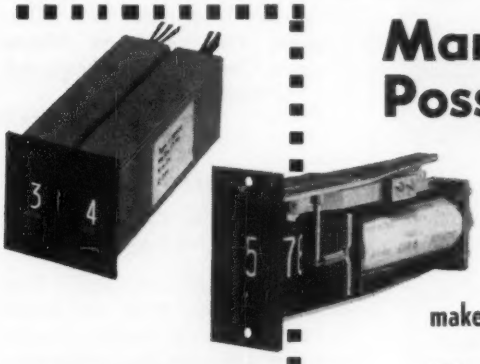
Blended Teflon, designated Miplon, makes use of inorganic additives to the fluorocarbon resin base to achieve improved physical characteristics. Material exceeds pure Teflon by a factor up to ten in resistance to deformation under load. Resistance to wear is increased by as much as 500 times, and compressive strength and stiffness can be increased four to five times. Additives do not lower desirable physical characteristics of Teflon, such as lubricity and chemical inertness. Uses are in mechanical parts, bearings, seals, piston rings, and gaskets for electrical, automotive, aviation, and chemical applications. **Modern Industrial Plastics Inc.**, 3337 N. Dixie Drive, Dayton 14, Ohio. G

Circle 550 on Page 19

Couplings and Hose

low-pressure assemblies are reusable

Hold-Fast low-pressure couplings are designed for general, low-pressure, hydraulic, and fluid-transfer service in the industrial, automotive, and agricultural fields. Attachment or removal from hose is quickly and easily accomplished without use of tools. Hose is forced over stem until it seats against bottom of protective cap. Reusable units are available in a wide range of styles and sizes. Low-pressure, one-cotton braid hose is furnished



Many Contact Possibilities . . .

make SODECO's 1TD *an extremely useful impulse counter*

A variety of contact possibilities at either 0 or 9, or both, either normally open or normally closed, make SODECO's 1TD impulse counter a useful tool for the design engineer. These single decade counters, available in either adding or subtracting models, can solve such problems as:

1. Any number may be installed in series to form a multi-digit counter.
2. Addition or subtraction with remote zero reset.
3. Transmission of numbers to a remote location with or without zero reset.
4. Remote predetermining by dial or punched cards, with contact operation at zero, with the possibility of recycling to an originally predetermined number.

SODECO 1TD ten or twenty-five impulse/sec. counters are compact (⅞" x 1¾" x 4⅜"), rugged units suitable for flush mounting. The large, easy to read numbers are 5/32" wide and 13/32" high. Power requirements are low—permitting their installation in electronic circuits. Their cost is reasonable, too.

Complete technical data is available, including circuitry recommended for a wide range of use. Write for Bulletin E-19 and E-44a.

LANDIS & GYR, INC.

45 West 45th Street, New York 36, New York

Circle 454 on Page 19

HEATING PROBLEMS?

Get help in a hurry from Chromalox

1 SEE OUR CATALOG IN SWEET'S PLANT ENGINEERING OR PRODUCT DESIGN FILE OR WRITE FOR COPY

Four pages of answers to all types of industrial and comfort heating problems. Application information, design features, complete data on sizes, ratings, temperatures to 1200°F. Controls and accessories. Also address listings of Chromalox Sales Engineering Representatives.

2 Call your Chromalox Man for the answers

For on-the-spot help, pick up the phone and call your Chromalox Representative. He has more than 15,000 standard types, sizes and ratings from which to select the best heater for your job.

For new or existing installations, Chromalox has: the world's most complete line of electric heating . . . the world's largest stock, for immediate shipment . . . personal "no obligation" assistance . . . factory design-engineering service for special applications. Chromalox answers are fast, clean, safe, accurate and economical. Call your Chromalox Man or write today.

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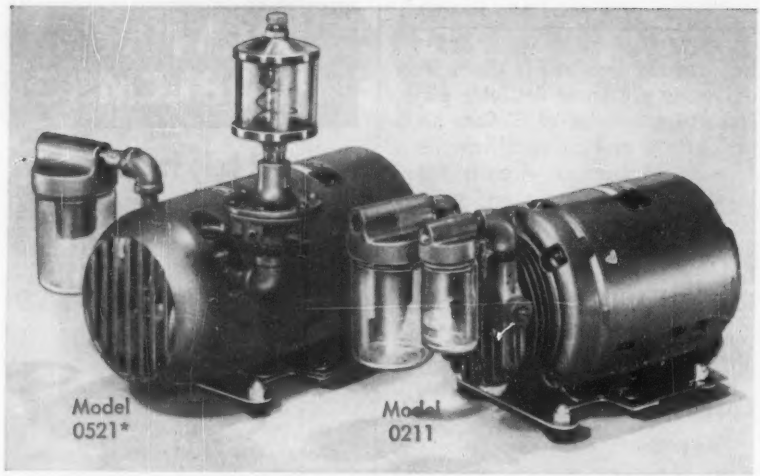
Circle 455 on Page 19



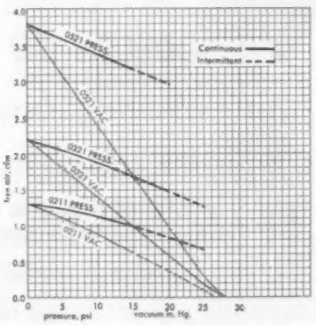
Get 10 Integral-Motor-Pump advantages in two **NEW** types (three models) of

GAST rotary vane AIR PUMPS

Designers seeking a dependable vacuum or pressure source for industrial instruments, vending machines, air gauge circuits, air sampling, laboratory equipment, printing and packaging machinery, etc., will find these *new* Gast Integral-Motor Air Pumps highly advantageous, especially where compactness and portability count. Consider these outstanding features:

1. Latest type G.E. "Form G" motors.
2. More compact than any pump of equal capacity.
3. Total weight reduced ⅓—cuts shipping costs.
4. Motor mounting time and labor eliminated.
5. Simple, trouble-free rotary-vane design.
6. Vanes take up their own wear automatically.
7. Positive displacement, pulseless air delivery.
8. Improved appearance—smoother exterior.
9. Dependable for original equipment; plant use.
10. Forced air fan cooling on Models 0321 & 0521.

Performance-Vacuum & Pressure



Write for new Bulletins V-356 and P-356!
GAST MANUFACTURING CORP., P. O. Box 117-P, Benton Harbor, Mich.

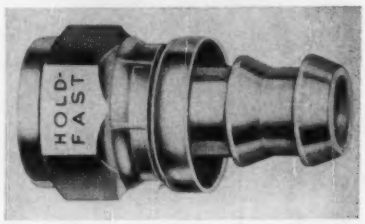
*0321 similar in appearance.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY
- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Circle 456 on Page 19



with synthetic-rubber inner tube and cover, or with abrasion-resistant, braided-cotton cover impregnated with oil and mildew-resistant synthetic-rubber compound. **Anchor Coupling Co. Inc.**, 342 N. Fourth St., Libertyville, Ill. J

Circle 551 on Page 19

Extruded Nylon Sheet

is available in widths to 40 in.

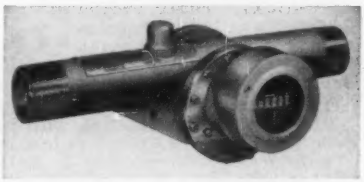
Type 6 nylon sheet is extruded in a variety of colors and thicknesses and in widths up to 40 in. Wide sheet is custom extruded in widths of 20 in. up, and can also be slit for special sizes. Applications include stamped parts on metal dies, washers, bearing surfaces, sight gages, and industrial glazing. Nylon sheet materials are available in thicknesses from 0.005 to 0.060 in. **Campco Div., Chicago Molded Products Corp.**, 2717 N. Normandy Ave., Chicago 35, Ill. I

Circle 552 on Page 19

Liquid Flowmeter

totalizes 20 to 220 gpm at 1500 psi working pressure

Model A5Y industrial liquid flowmeter is nonelectrical and simple in design, with magnetic-output coupling driving a seven-digit number-wheel register. Meter totalizes 20 to 220 gpm at 1500 psi working



pressure. Constructed of stainless steel, meter handles corrosive and hard-to-handle liquids, LP gas, dry fuel gases, and water. It is based on vortex-velocity principle of flow measurement. **Rotron Controls Corp.**, Woodstock, N. Y. D

Circle 553 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Isometric Gear Guide

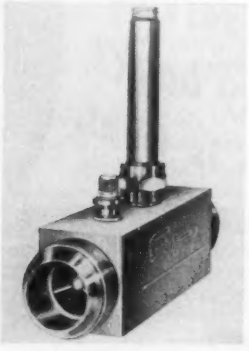
for 8, 12, 16, and 24 diametral pitches

Underlay drawing aid has a rack and 21 spur-gear faces having 6 to 48 simplified teeth in isometric projection. Four diametral pitches of 8, 12, 16, and 24 are provided. Tooth form is based on rack of American Standard 20-deg involute system. Guide is designed for spur, helical, bevel, internal, herringbone, and worm gears, and also for worms, racks, splines, ratchets, and sprockets. It is adaptable to other circular forms having evenly spaced projections, such as cutters, pump rotors, turbines, and commutators. Guide can also be used for perspective projection. **Graphicraft**, P. O. Box 509, Westport, Conn. B

Circle 554 on Page 19

Mass Flowmeter

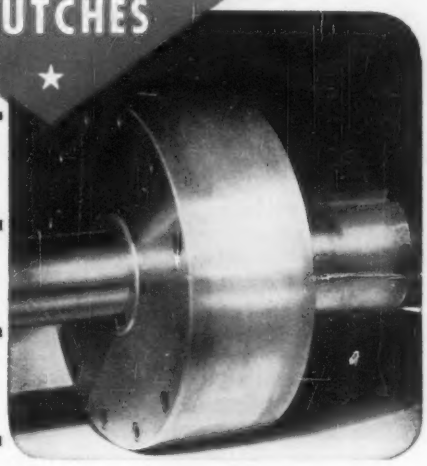
unit with only one moving part provides high accuracy



New mass flowmeter is a compact, lightweight instrument with only one moving part. It provides accuracy of ± 1 per cent of instantaneous rate and handles a wide variety of liquids up to rates of 1 million lb per hr. Unit consists of a variable-force element and a volumetric element in a single meter body. Variable-force element produces a voltage proportional to volume flow rate squared times fluid

FOR POWER CONTROL DESIGNS USE
HILLIARD
Over-Running
CLUTCHES

1. LONG LIFE because the rolls have no localized wear points.
2. NO JAMMING even after long wear.
3. ACCURATE because of individual spring pressure on each roll.
4. RENEWABLE CAM SURFACES for increased life without machining or new parts.



50 YEARS of satisfactory service proves you can depend on Hilliard Over-Running Clutches and Couplings for long service on—

- DUAL DRIVES for pumps, fans, blowers and boiler stokers. (Many installations have a record of over 20 years without repair.)
- TWO SPEED DRIVES for dry cleaning machines, laundry equipment, conveyors, paper processing machines, slitters, forming rolls and automatic machinery.
- RATCHET ACTION for printing press ink rolls, coal feeders, press feeds, honing machines, bakery equipment and conveyors.
- BACK STOP SERVICE on textile machines, speed reducers, elevating conveyors and in combination with ratchet feeds.
- WRITE TODAY FOR BULLETIN 231 WITH COMPLETE INFORMATION.

OTHER HILLIARD CLUTCHES:

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.

★ CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

THE HILLIARD CORPORATION
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

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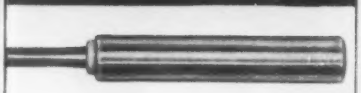
IN CANADA: UPTON • BRADEEN • JAMES, LTD.

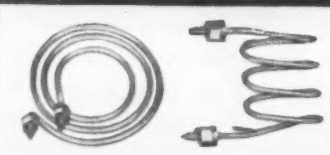
Circle 457 on Page 19

Solve Your
HOT PROBLEMS
with
VULCAN
VERSATILITY
in

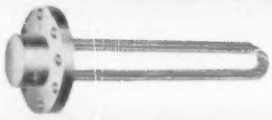


. . . CARTRIDGE HEATERS

. . . STRIP HEATERS



. . . TUBULAR HEATERS



. . . IMMERSION HEATERS

When you have hot problems in electric heat, you get a speedy solution through *Vulcan Versatility* — in design, engineering and manufacturing. Complete line includes finned, ring, band and pressuring heaters. All elements are available in a wide variety of sizes, wattage and voltage ratings, sheath materials, lead wires and terminals.

Write for catalog

VULCAN
ELECTRIC COMPANY
DANVERS 6, MASS.

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

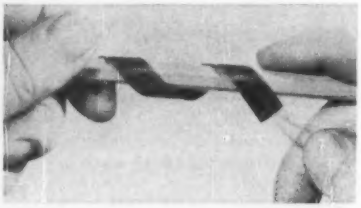
Circle 458 on Page 19

density. Volumetric element produces a frequency proportional to volume flow rate. By dividing the latter electronically into the former, mass flow rate is calculated. **Fischer & Porter Co.**, 914 Jacksonville Rd., Hatboro, Pa. E

Circle 555 on Page 19

Thermal Ribbon

for applications to 260 C



Thermal ribbon for temperature measurement and control applications to 260 C is flexible and less than 0.020-in. thick. Model S6A measures ½ x 4 in. and is furnished with pressure-sensitive tape for installation to flat, curved, or irregular surfaces. Resistance is 676 ohms at 25 C, varying at a rate of 3.06 ohms per deg at 25 C. Calibration curve from −60 to 260 C is furnished for quick conversion of resistance measurements to temperature. **Minco Products Inc.**, 740 Washington Ave. N., Minneapolis 1, Minn. J

Circle 556 on Page 19

Sensitized Film

for producing duplicate originals

Perma-Scale intermediate film with Mylar base provides ease of eradication, excellent toughness, and dimensional stability. Designed for producing duplicate originals, film is sensitized on glossy reverse side so that repeated eradication on the glossy surface cannot affect front matte surface for making engineering changes. Lines from original drawing are easily eradicated with solvent-type chemical or typewriter eraser and shield. Film has tensile strength of 20,000 psi, tensile modulus of 550,000 psi, and flex life of 20,000 cycles. **Eugene Dietzgen Co.**, Dept. M-1, 2425 N. Sheffield Ave., Chicago 14, Ill.

Circle 557 on Page 19

Longer,
trouble-free service
or your money back!
Your opinion is final.
Write for literature and service data sheets, or send prints and condition of operation for recommendations and quotations.
PROMET
ENGINEERED BRONZE BEARINGS
BUSHINGS
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Inquire About Promet Fully Machined
CORED & SOLID BRONZE BAR STOCK
Saves Time, Tools & Money!
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Lorain, Ohio, U. S. A.

Circle 459 on Page 19

THE ENGINEER'S

Library

Recent Books

Ordinary Differential Equations. *By Wilfred Kaplan, associate professor of mathematics, University of Michigan; 534 pages, 6 by 9 in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from* MACHINE DESIGN; *$8.50 per copy postpaid.*

This introductory textbook emphasizes functional analysis, or the use of the input-output relationship. This point of view is used to a great extent in systems analysis or instrumentation. Rather than presenting special devices for solving particular problems, this book stresses the fundamental relationships involved.

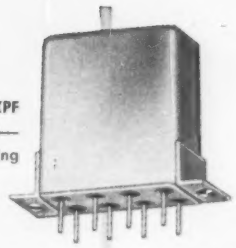
Gear Ratio Tables for 4-, 6-, and 8-Gear Combinations. *By Earle Buckingham; 95 pages, 8½ by 11 in., clothbound; published by and available from The Industrial Press, 93 Worth St., New York 13, N. Y.; $5.00 per copy.*

New tables of pairs of consecutive numbers from 1000 to over 40,000, with factors of each number, the ratio of the smaller to the larger number, and the reciprocal of that ratio, are given in this book. Included also are Brocot's tables of gear ratios which list all ratios obtainable with any combination of two gears provided the number of teeth in each gear is 120 or less. Also, factors other than ratios that enter into the design of gear trains are discussed.

Manufacturers' Publications

Arc Welding in Machinery Design and Manufacture. *209 pages, 6 by 9 in., clothbound; published by and available from James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio; $2.00 per copy.*

This book discusses welding problems encountered in machine design and manufacture, and suggests where improvement can be made through application of arc welding.



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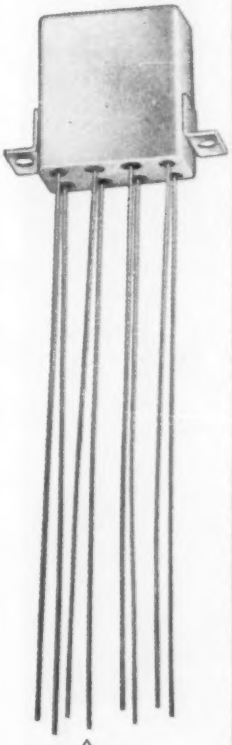

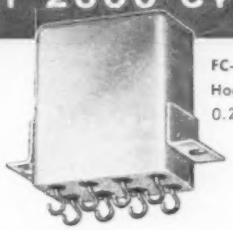

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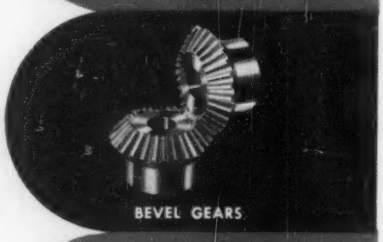

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Presented as a guide to the effective use of welding, this book is divided into two parts. Part 1 contains a guide to design appraisal and information on welding properties and characteristics. Part 2 discusses the welding problem from the standpoint of shapes and types of structures, such as frames, bases, rotating parts, housings, and component parts under light, medium, and heavy loads.

Government Publications

Investigation of Heat Treatments and Mechanical Properties of High Strength Steel Castings, PB 131638. *By J. W. A. Tyler and P. J. Ahearn; 33 pages, 8 by 10½ in., paperbound and side stapled; published by and available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $1.00 per copy.*

Tensile test results and Charpy impact data are listed for various heat-treatment methods used on castings of a high-silicon steel and SAE 4340 steel modified with 0.15 per cent vanadium. High-silicon steel castings have a lower ductility at the thicker sections than the SAE 4340 steel but can be heat treated to a strength level of 290,000 psi with a yield stress of 215,000 psi at 0.1 per cent offset.

Proceedings of the Fourth Sagamore Ordnance Materials Research Conference: High Temperature Materials, Their Strength Potentials and Limitations, PB 131834. *361 pages, 8 by 10½ in., paperbound and side stapled; published by and available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; $5.00 per copy.*

This report contains 12 technical papers presented by metallurgical experts from industry, universities, and the government at a conference sponsored by the U. S. Army Ordnance Corps.

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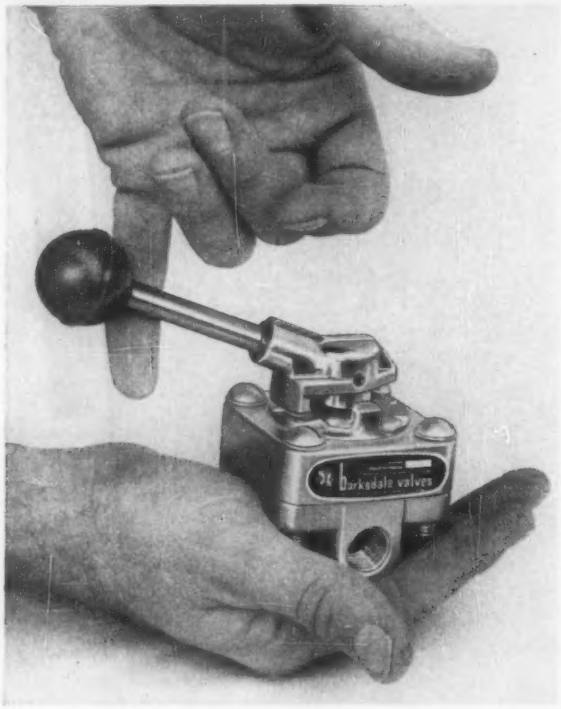

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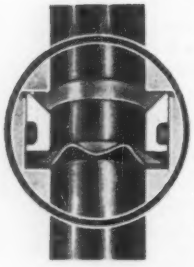

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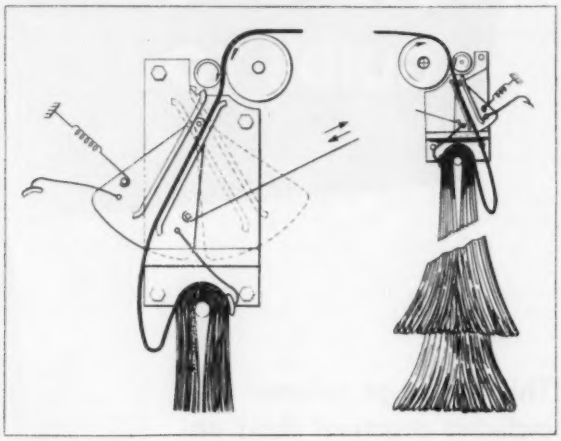
NOTEWORTHY

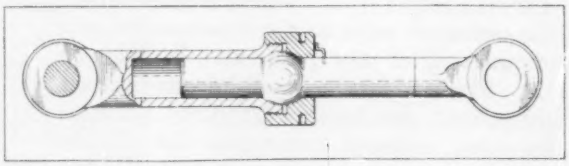
Patents

High-Speed Tape Handling System



Swinging guides, which cause tape to be stored in festoons, enable a tape handling system to process 7500 ft of tape in one continuous length at 200 fps. From rest, the tape reaches this speed in 0.8 millisecond. This performance is achieved without breaking the tape because the mass of tape accelerated is only that in one-half of one festoon. In each half of the system a large driving wheel turns constantly in a feed-in direction. A smaller wheel holds the tape against the drive wheel when feed-in is desired. The swinging guide is activated by a solenoid controlled, in turn, by a cam-operated contact. The lengths of festoons can be changed by adjusting the cam. *Patent* 2,855,196 *assigned to Hughes Aircraft Co., Culver City, Calif., by Robert W. Quirk.*

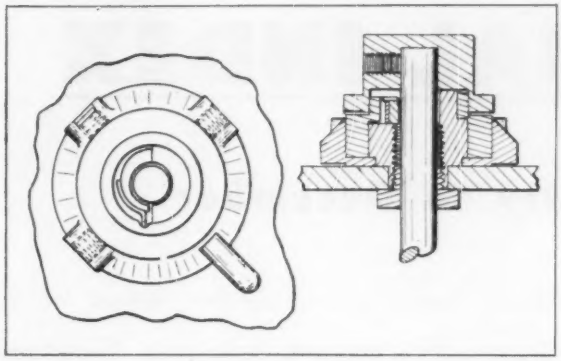
Shock-Absorbing Link



Resistance to deformation of telescoping members in a built-up link cushions compressive shock loads. When the link is axially shock-loaded in compression, a male member is forced farther into the tubular length of a female member, and a spherical section of the male part tends to rupture the wall of the tube. The extent of rupture is read on a graduated collar which is turned to take up relative linear displacement caused by the shock loading. *Patent* 2,857,056 *assigned to General Motors Corp., Detroit, by Thomas B. Dilworth.*

Shaft-Setting Lock

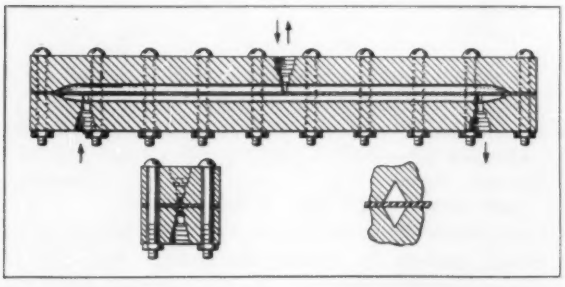
Interaction of a jam-spring and a semicircular wedge enables a shaft to be locked at any angular setting without disturbing the setting in the locking operation. The lock mechanism is actuated by rotation of



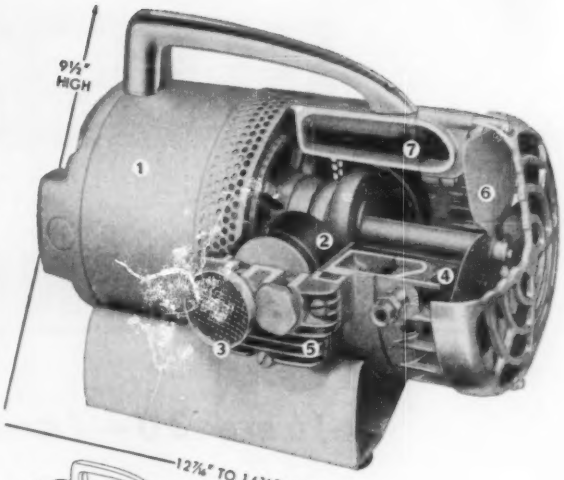
a tube which carries a projecting lever. Inside the tube is the shaft and a semicircular projection of a stationary hub. Opposite this projection is a floating semicircular wedge, the thick end of which contacts the stationary projection, and a curved spring, one end of which is carried in a slot in the surrounding tube. Torque exerted on the tube causes the spring to ride up the wedge, thus jamming the shaft to the stationary hub. *Patent* 2,857,186 *assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, by Ralph A. Bonetti.*

Flexible Flow-Damping Nozzle

A long, narrow passage, divided in half over its entire length by a resilient diaphragm, provides uniform,



low-volume flow of fluids containing minute solid particles which would clog other controls such as gates and needle valves. The upper channel is filled with an incompressible fluid at constant pressure. The lower channel carries the transmitted fluid which is delivered to the inlet at fluctuating pressure and volume. From one end of the passage to the other, graduated pressure differentials between the channels cause corresponding deflections of the diaphragm. These dimensional changes cause the transmitted-fluid chamber to appear and function like a long nozzle. *Patent* 2,850,038 *assigned to Houdry Process Corp., Wilmington, Del., by Hubert A. Shabaker.*



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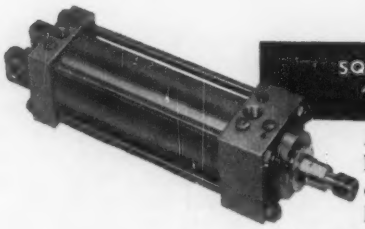

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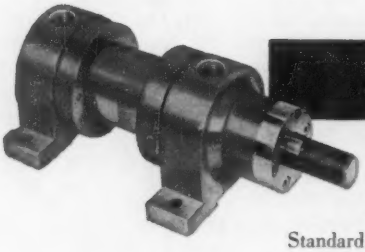

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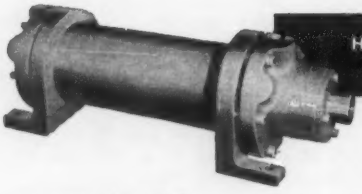

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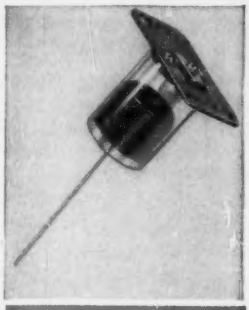

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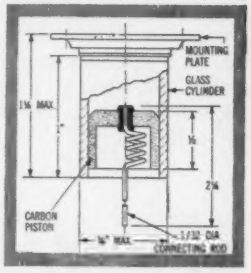

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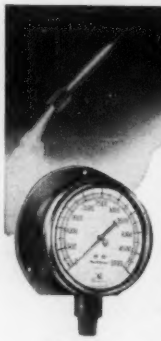

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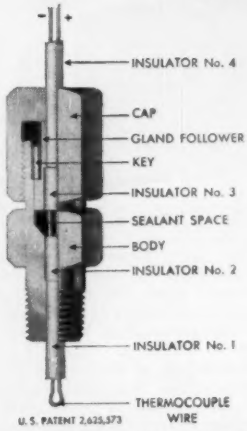

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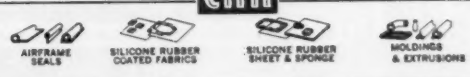

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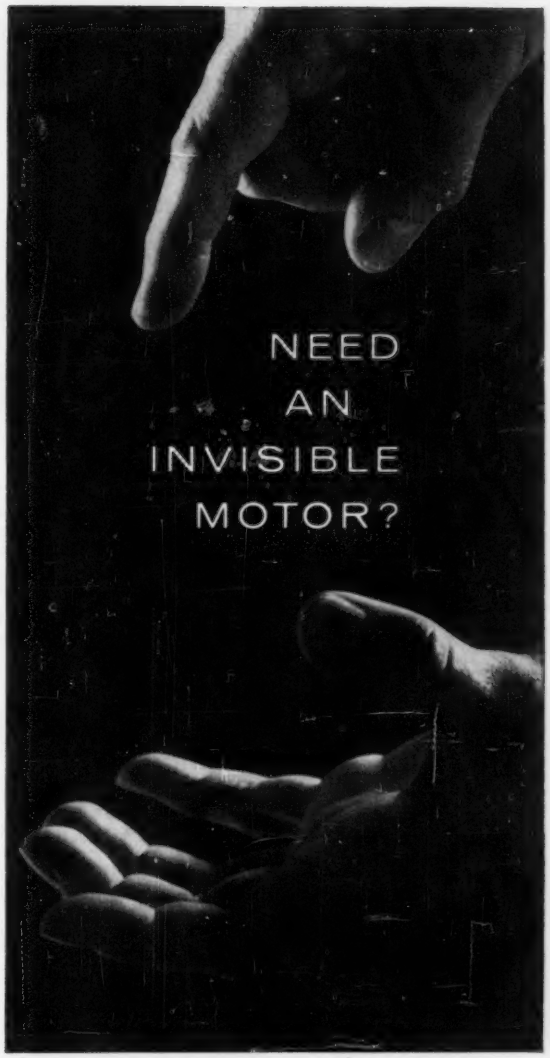

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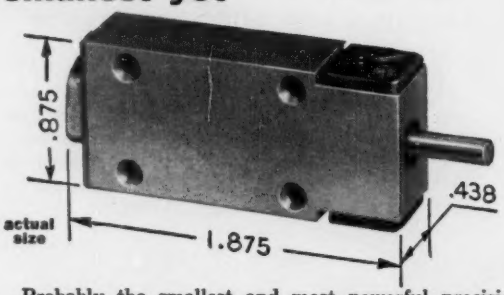

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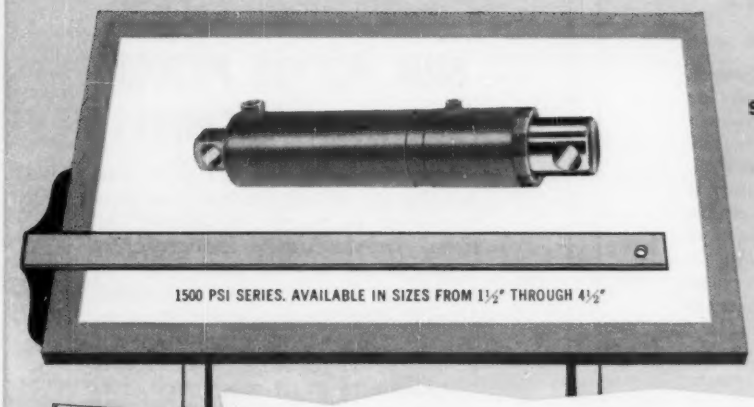

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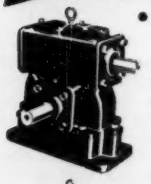

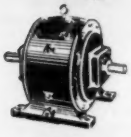

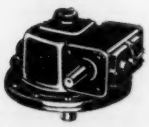

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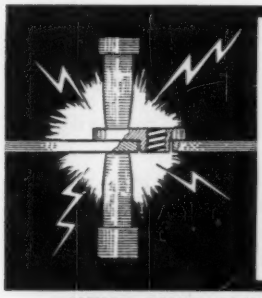

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8MM MOTION PICTURE EQUIPMENT ENGINEERS

THE PHOTOGRAPHIC INDUSTRY'S MOST EXCITING NEW PRODUCTS PROGRAM HAS CREATED OPPORTUNITIES IN DESIGN, DEVELOPMENT, RESEARCH, AND PRODUCTION ENGINEERING AT ARGUS CAMERAS. THESE ARE SPECIFIC OPENINGS IN OUR 8MM MOVIE PROGRAM WHICH REQUIRE GRADUATE ENGINEERS WITH EXPERIENCE IN ENGINEERING AND MANUFACTURING AMATEUR MOTION PICTURE EQUIPMENT. THIS IS A RARE OPPORTUNITY TO UTILIZE YOUR EXPERIENCE BY JOINING US AS A PROJECT LEADER IN OUR GROWING NEW PRODUCT ACTIVITIES.

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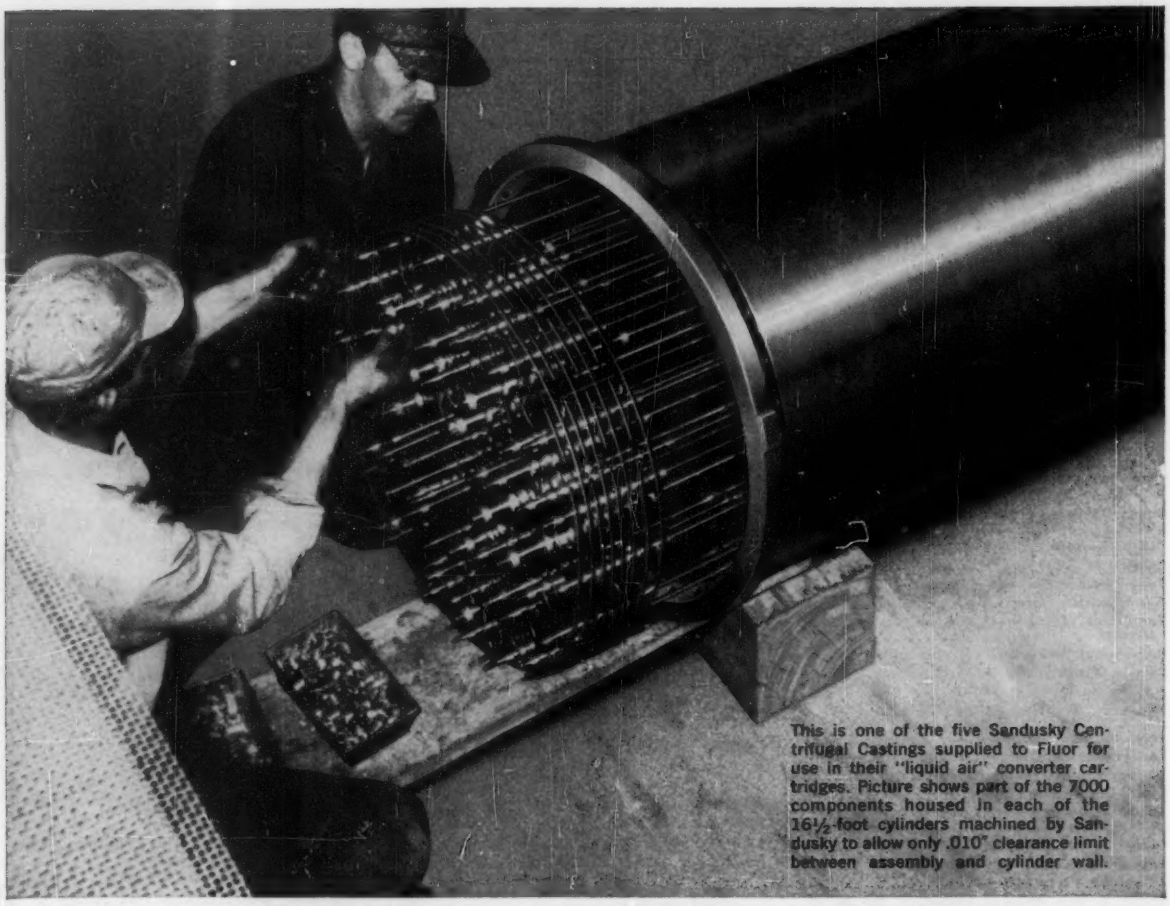

This is one of the five Sandusky Centrifugal Castings supplied to Fluor for use in their "liquid air" converter cartridges. Picture shows part of the 7000 components housed in each of the 16½-foot cylinders machined by Sandusky to allow only .010" clearance limit between assembly and cylinder wall.

SOLVED by Sandusky Centrifugal Castings:

This difficult precision-cost-delivery problem for the FLUOR PRODUCTS COMPANY.

Sandusky Quality Centrifugal Castings

Types: Rolls, Sleeves, Rings, Bearings, Bushings, Liners, Bands, Drums, Cylinders, Tubes, Shells, Retorts, Pressure Vessels, Pressure Piping

Sizes: From 7" to 54" O.D.—Lengths up to 33 feet

Materials: Stainless, Carbon and Low-Alloy Steels; full range of Copper-Base and Nickel-Base Alloys

Dimensional stability of Sandusky Centrifugal Castings enabled the Fluor Products Company to fit more than 7,000 precision parts into each of 5 identical cylinders supplied by Sandusky for use as ammonia synthesis converter cartridges.

Centrifugally cast of a modified CF8 (Type 304L) stainless steel, each cylinder was machined to finish dimensions 27¾" O.D., 26⅝" I.D., 199" long. The bore, surface finished to 35 micro inches, was held to .005" maximum out-of-roundness and .008" maximum taper.

What is more important, to meet Fluor's difficult assembly problems these large cylinders would have to be able to retain these carefully machined dimensions.

"The Fluor Products Company Engineers selected Sandusky Centrifugal Castings because of the stringent specifications, critical delivery requirements and competitive cost of this project. This was the first experience with such centrifugally cast products by the Fluor Products Company; and, the Sandusky Foundry and Machine Company people assisted in making this an extremely satisfactory and profitable project."

While you may have entirely different cylindrical design requirements, Sandusky Centrifugal Castings may well provide a similar cost-cutting answer. We would be pleased to have your inquiries.

SANDUSKY (S) **CENTRIFUGAL CASTINGS**

FOUNDRY & MACHINE CO.

SANDUSKY, OHIO Stainless, Carbon, Low Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

buy your horsepower at the output shaft

Speed reducer problems involve more than just gear ratios. Horsepower, torque, overhung loads and duty cycle are considerations that require performance matching of motor and reducer. When you specify Master Gearmotors you eliminate dual responsibility for overall performance.

Master Gearmotors are packaged components, engineered to meet your requirements from line voltage to keyway dimensions. Motor and reducer are built as a single, rigidly aligned unit. These compact drives offer maximum efficiency and durability at minimum cost.

You can reduce engineering and assembly expenses by giving Master the responsibility for the entire power package. With Master Gearmotors you buy your horsepower where you need it, at the output shaft.

Vertical and horizontal, right angle and parallel shaft, worm, helical and herringbone gearing—⅛ thru 125 hp.

Product of Master Electric Division of Reliance Electric and Engineering Company, manufacturers of a-c. motors, Reeves Drives, V★S Drives, Super 'T', D-c. Motors, generators, controls, and engineered drive systems. E1009

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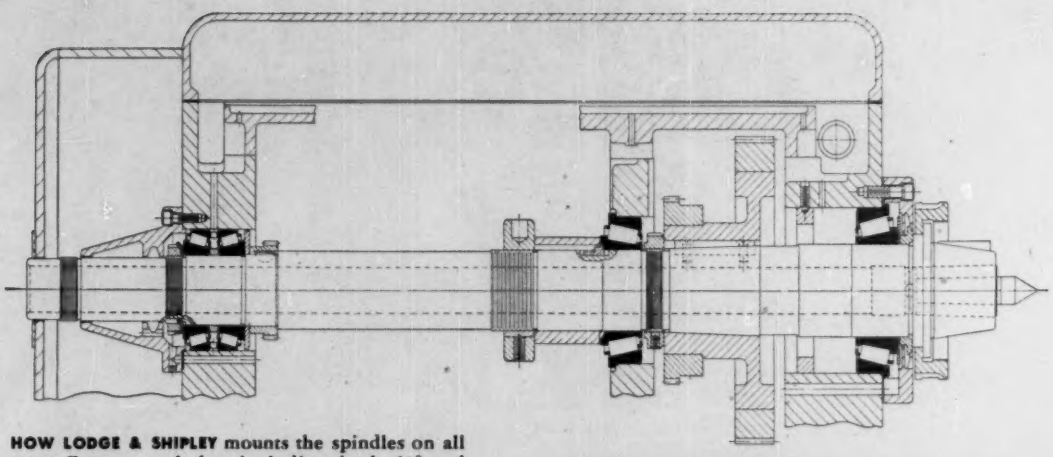
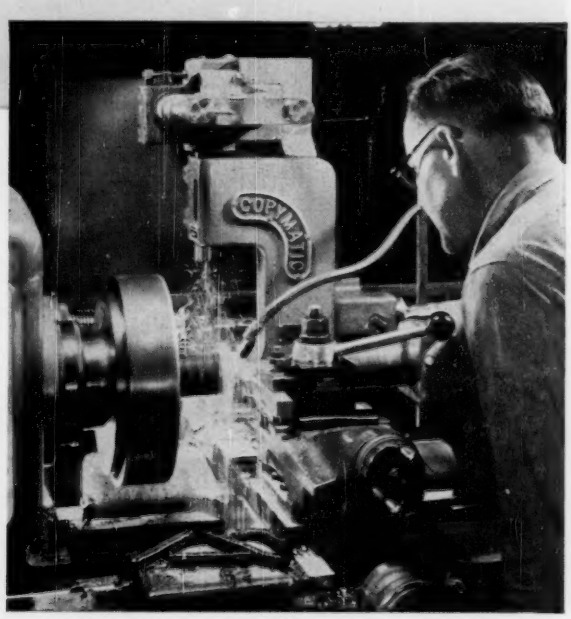


HOW LODGE & SHIPLEY mounts the spindles on all 2013 Powerturn lathes including both 45° and 90° Copymatics on Timken bearings to get extra rigidity, maintain accuracy, reduce maintenance.



New type lathe ups production 200%, saves users an estimated $8,000 a year

...one secret—TIMKEN® bearings on the spindle

"Production increases as high as 200%"..."Overall savings estimated at $8,000 a year"—read user reports about the new 2013 Powerturn 90° Copymatic Lathe. One important reason for such exceptional results is that Lodge & Shipley mounts the spindle on Timken® tapered roller bearings. Timken bearings give it the vital extra rigidity and hold runout to the minimum needed for tracer accuracy.

How spindle is held rigid. Timken bearings hold the spindle in positive alignment. They take *both* radial and thrust loads in any combination, because of their tapered design. And because of full line contact between rollers and races, Timken bearings have extra load-carrying capacity.

Why heavy shocks are absorbed. Case-carburization of Timken bearings' rollers and races gives them hard, wear-resistant surfaces and tough, shock-resistant cores.

How friction is virtually eliminated. Timken bearings are geometrically designed to roll true. And they're precision-made to live up to their design. They run smoother—last longer.

We even make our own electric furnace fine alloy steel, for extra quality control. We're America's only bearing maker that does. To get all these advantages, always specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

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